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# COMPARATIVE EFFECTS OF THREE MATACIL® FIELD FORMULATIONS ON STREAM BENTHOS AND FISH

S.B. Holmes & P.D. Kingsbury

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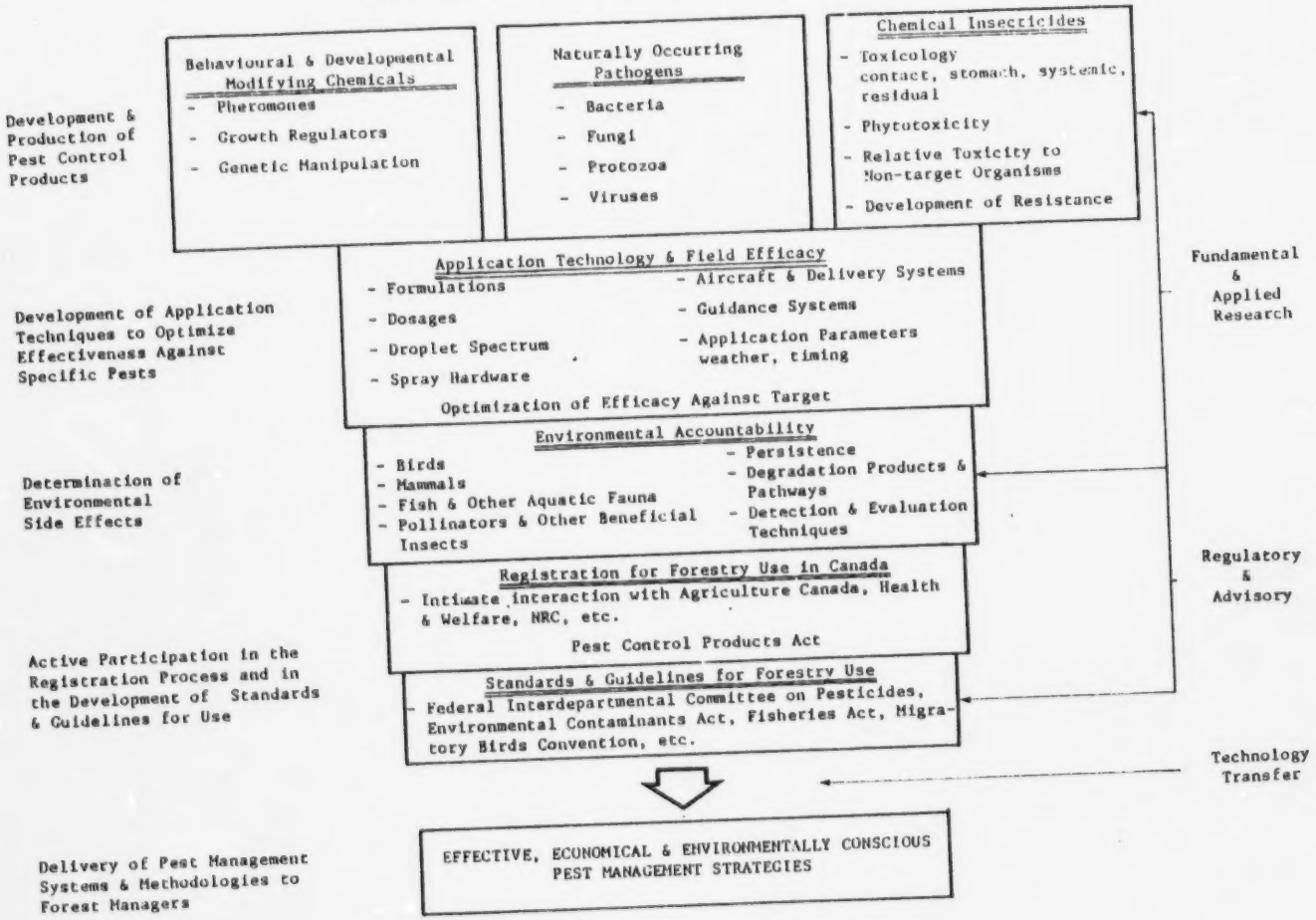
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# COMPARATIVE EFFECTS OF THREE MATACIL® FIELD FORMULATIONS ON STREAM BENTHOS AND FISH

S.B. HOLMES and P.D. KINGSBURY

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DEPARTMENT OF THE ENVIRONMENT

December 1982

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## ABSTRACT

The effects of three MATACIL® field formulations and some of their components on the invertebrate fauna of a cold water trout stream were studied near Searchmont, Ontario. Treatments were made by hand applying the test materials to a section of stream using a Micron ULVA sprayer. Applications of MATACIL® 1.8D + ID 585 and MATACIL® 1.8F + Atlox 3409 F + water both resulted in increased drifts and population reductions of some invertebrate taxa. Collembola and Gerridae appeared to be most affected by the MATACIL® 1.8D + ID 585 treatment and Simuliidae, Leuctridae, Baetidae, Philopotamidae and Hydroptilidae by the MATACIL® 1.8F + Atlox 3409F + water treatment. Peak aminocarb levels in water following these treatments (35.4 and 256.1 ppb respectively) were higher than those measured following operational applications of MATACIL® in Quebec and Newfoundland. No impacts were evident following applications of MATACIL® 1.8F + ID 585 and MATACIL® 1.8F + Atlox 3409F + water, for which peak levels of aminocarb in water were 127.2 and 29.2 ppb respectively. Although an application of Sunspray 7-N + ID 585 resulted in increased drifts of Collembola and Leuctridae, no impacts were associated with an application of Sunspray 7-N + Atlox 3409F + water, even though applied at a higher dosage rate. There was no mortality of rainbow trout fingerlings held in cages in the treated stream sections. Fish did accumulate aminocarb residues in their tissues, however. Bioaccumulation ratios were 0.48 for the MATACIL® 1.8D + ID 585 treatment, 0.25 for the MATACIL® 1.8F + ID 585 treatment and 0.50 for the MATACIL® 1.8F + Atlox 3409 F + water treatment.

## RÉSUMÉ

Nous avons étudié près de Searchmont, en Ontario, les effets de trois préparations de MATACIL® et quelques-uns de leurs constituants sur la faune invertébrée d'un ruisseau à truites et à eau froide. Les épandages à l'aide d'un épandeur Micron ULVA ont été manuels et se sont limités à un tronçon du ruisseau. Le MATACIL® 1.8D + ID 585 et le MATACIL® 1.8F + Atlox 3409F + eau ont augmenté la dérive et réduit les populations de certains taxons d'invertébrés. Les collemboles et les gerridés ont semblé les plus touchés par le premier traitement tandis que les simuliidés, les leuctridés. les baetidés, les philopotamidés et les hydroptilidés l'ont été par le second. Les concentrations maximales d'aminocarbe dans l'eau, à la suite de ces traitements (35.4 et 256.1 ppm respectivement), étaient supérieures à celles mesurées à suite d'épandages opérationels en grand de MATACIL® au Québec et à Terre-Neuve. Aucune répercussion n'était évidente à la suite des traitements au MATACIL® 1.8F + ID 585 et au MATACIL® 1.8F + Atlox 3409F + eau, pour lesquels les concentrations maximales d'aminocarbe dans l'eau étaient de 127.2 et de 29.2 ppm respectivement. Même si l'application de Sunspray 7-N + ID 585 a provoqué un accroissement de la dérive de collemboles et de leuctridés, aucune répercussion n'a été reliée au Sunspray 7-N + Atlox 3409F + eau, mème si dans ce dernier cas la dose était plus élevée. Il n'y a eau aucune mortalité des alevins de truites arc-en-ciel gardés dans des cages dans les tronçons du ruisseau traiteé. Cependant, il y a eu accumulation d'aminocarbe dans leurs tissus. Les taux de bio-accumulation étaient de 0.48 pour le MATACIL® 1.8D + ID 585, de 0.25 pour le MATACIL® 1.8F + ID 585 et de 0.50 pour le MATACIL® 1.8F + Atlox 3409F + eau.

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## INTRODUCTION

MATACIL®, containing the carbamate insecticide aminocarb (4-(dimethylamino)-3-methylphenol methylcarbamate), has been used extensively since 1971 to control spruce budworm, *Choristoneura fumiferana* Clemens, in eastern Canada. Although environmental impact monitoring programs in Quebec, New Brunswick and Newfoundland have detected few adverse effects on forest ecosystems sprayed with MATACIL® (Holmes and Kingsbury, 1980; Kingsbury et al., 1981), recent laboratory studies have shown that the MATACIL®1.8D* formulation currently in use is more toxic to certain aquatic organisms than the pure active ingredient aminocarb alone. This is due to the high toxicity of nonyl phenol, a so-called "inert" component of the formulation, to aquatic organisms (McLeese et al., 1980a and b; Ernst et al., 1981).

In an attempt to reduce the non-target toxicity of MATACIL® field formulations, Chemagro Ltd. has recently developed a new flowable formulation, MATACIL®1.8F**, which does not contain nonyl phenol. This formulation has an added advantage in that it can be applied either as an emulsion in water or suspended in a suitable carrier oil. Initial testing of the new MATACIL®1.8F flowable formulation was begun by the Forest Pest Management Institute in 1981 and included laboratory toxicity testing, small block field efficacy trials and environmental impact studies. The results of an experiment to compare the impacts of the MATACIL® 1.8D and MATACIL®1.8F field formulations on certain components of a stream ecosystem are reported here.

## SITE DESCRIPTION

Environmental impact studies were conducted in Matt Brook, a small, permanent, headwater trout stream which flows into the Goulais River approximately 16 km north of the town of Searchmont, Ontario (Figure 1). Within the study area, Matt Brook is 1-3 m wide, 10-50 cm deep and is characterized by small, fast-flowing, riffle areas with sandy-gravel substrates interspersed with large pools with little current and silt substrates. Undercut banks and brush piles provide substantial cover for a resident population of native brook trout (*Salvelinus fontinalis* Mitchill). Discharge was measured six times over the course of the study and ranged from a high of 340 L/sec on 4 June 1981 to a low of 10 L/sec on 21 July 1981.

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*MATACIL® 1.8D = 1.8 lb of active ingredient (AI)/Imp. gal.
= 1.5 lb AI/U.S. gal
= 180 g AI/L

**MATACIL® 1.8F = 1.8 lb AI/Imp. gal
= 1.5 lb AI/U.S. gal
= 180 g AI/L

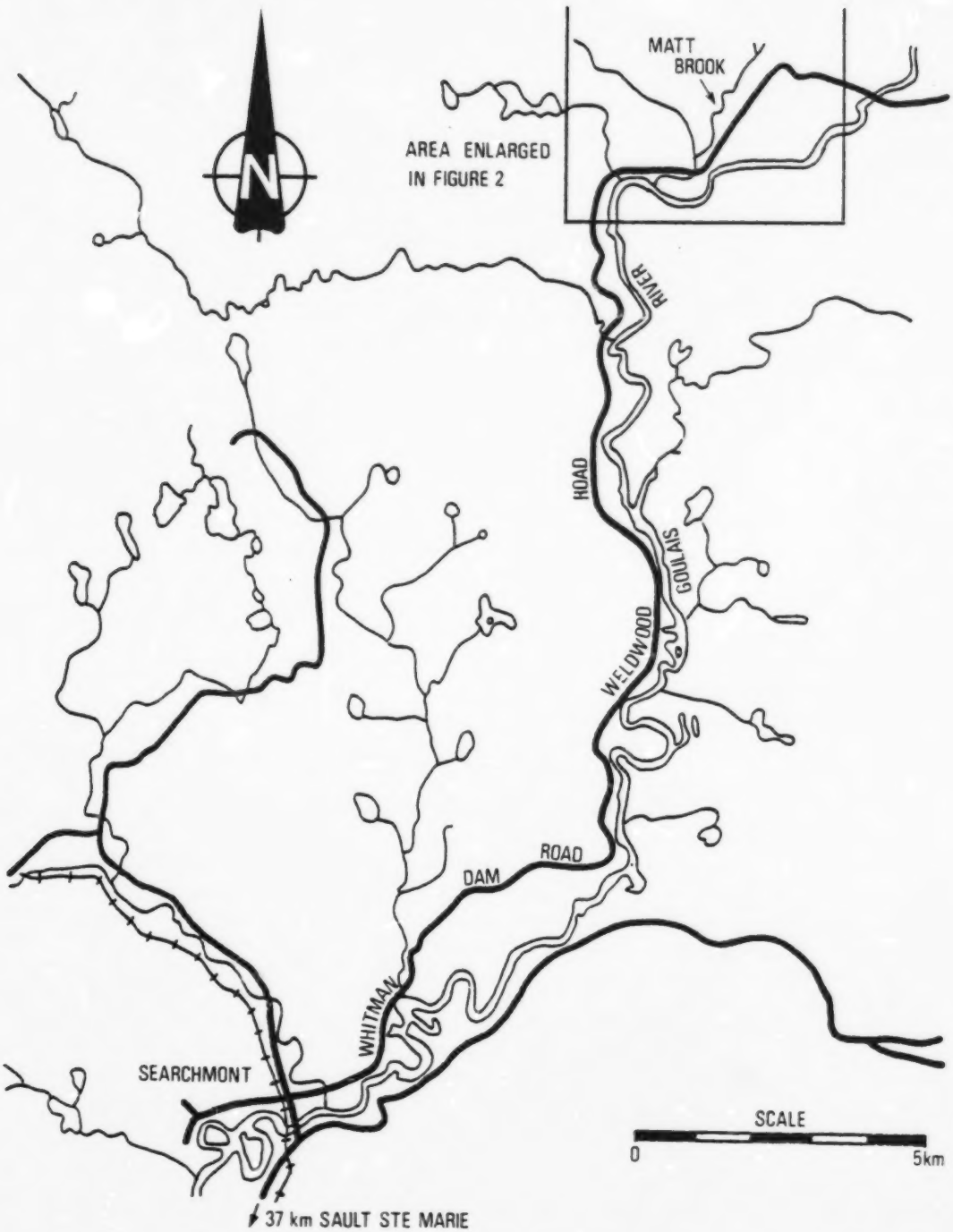


Figure 1. Location of study area near Searchmont, Ontario.

## METHODS

### Formulation and Application

Stock solutions of the insecticides were mixed to simulate the actual spray formulations which would be applied in operational applications of MATACIL® 1.8D and MATACIL® 1.8F at the maximum allowable single dosage rate of 87.5 g AI/ha in 1.46 L/ha total spray volume (Table 1). Stock solutions of Sunspray 7-N, a component of MATACIL® 1.8F insecticide, were prepared to approximate the water and oil formulations of MATACIL® 1.8F minus the active ingredient aminocarb.

Solution 1 was applied first to the furthest downstream section of Matt Brook. After allowing sufficient time to complete biological and residue sampling, a second application was made approximately 250 m upstream from the first site using Solution 2. This procedure was repeated for Solutions 3, 4, 5 and 6 with progressive moves upstream for each application. The minimum time between any two consecutive applications was 6 days, and the minimum distance between treatment sites was 200 m (Fig. 2).

A Micron 'ULVA' Sprayer[1] was used to apply the test materials (Fig. 3). According to the manufacturer's specifications, this ultra-low-volume applicator is capable of producing a relatively narrow spectrum of droplet sizes centering around 70 μ diameter. The sprayer was calibrated in the laboratory to emit water at a rate of aproximately 40 ml/min. In actual field use the emission rate varied between 24-52 ml/min. All applications were 5 minutes in duration. Using the known emission rates and an estimate of stream discharge at the time of the applications, it was possible to calculate the 'expected' peak concentrations of Sunspray 7-N or aminocarb in water for each treatment (Table 2).

After completion of the third application (MATACIL® 1.8F + Atlox 3409F + Rhodamine B Dye + Water) it was noted that residues of aminocarb in water were much lower than expected, suggesting that there might have been some problem with the spray formulation. Subsequent GLC analysis of the MATACIL® 1.8F sample provided by Chemagro Ltd. revealed that this sample contained only 33.7 mg AI/ml rather than the 180 mg AI/ml specified on the label and used as a basis for the calculation of expected aminocarb concentrations in water. It was, therefore, necessary to repeat this treatment at the end of the experiment, after a replacement sample had been received from the company. Presumably the only difference between the two samples was in the amount of active ingredient they contained, and therefore both applications will be considered in this report. To avoid confusion, the first of these two treatments will subsequently be referred to as the MATACIL® 1.8F X treatment.

---

[1] Micron Sprayers Ltd., Herefordshire, England.

Table 1. Composition of spray formulations used to treat Matt Brook between 4 June and 21 July 1981.*

| | Solution 1 | Solution 2 | Solution 3 | Solution 4 | Solution 5 | Solution 6 |
|---|---|---|---|---|---|---|
| Date | 4 June 1981 | 10 June 1981 | 16 June 1981 | 7 July 1981 | 14 July 1981 | 21 July 1981 |
| Time of Application | 0745-0750 EDT | 0800-0805 EDT | 0840-0845 EDT | 0740-0745 EDT | 0755-0800 EDT | 0755-0800 EDT |
| Insecticide[1] | - | - | MATACIL® 1.8F X** 33.3% | MATACIL® 1.8D 33.3% | MATACIL® 1.8F 33.3% | MATACIL® 1.8F 33.3% |
| Solvent[2] | Sunspray 7-N 25% | Sunspray 7-N 25% | - | - | - | - |
| Emulsifier[3] | - | Atlox 3409F 1.25% | Atlox 3409F 1.25% | - | - | Atlox 3409F 1.25% |
| Dye[4] | Automate Red 0.5% | Rhodamine B 0.5% | Rhodamine B 0.5% | Automate Red 0.5% | Automate Red 0.5% | Rhodamine B 0.5% |
| Carrier[5] | ID 585 74.5% | Water 73.25% | Water 64.95% | ID 585 66.2% | ID 585 66.2% | Water 64.95% |

* the proportions of components in the spray formulations are expressed on a V/V basis.
** MATACIL® 1.8F X insecticide containing 33.7 mg AI/ml; approximately 18.7% of label specification
1 MATACIL® 1.8D and MATACIL® 1.8F supplied by Chemagro Ltd., Mississauga, Ont.
2 Sunspray 7-N supplied by Sunoco Inc., Toronto, Ont.
3 Atlox 3409F supplied by Atlas Chemical Industries, Brantford, Ont.
4 Automate Red Dye supplied by Morton-Williams Canada Ltd., Ajax, Ont.
Rhodamine B Dye supplied by Dupont of Canada Ltd., Montreal, P.Q.
5 Insecticide Diluent 585 supplied by Shell Canada Ltd., Toronto, Ont.

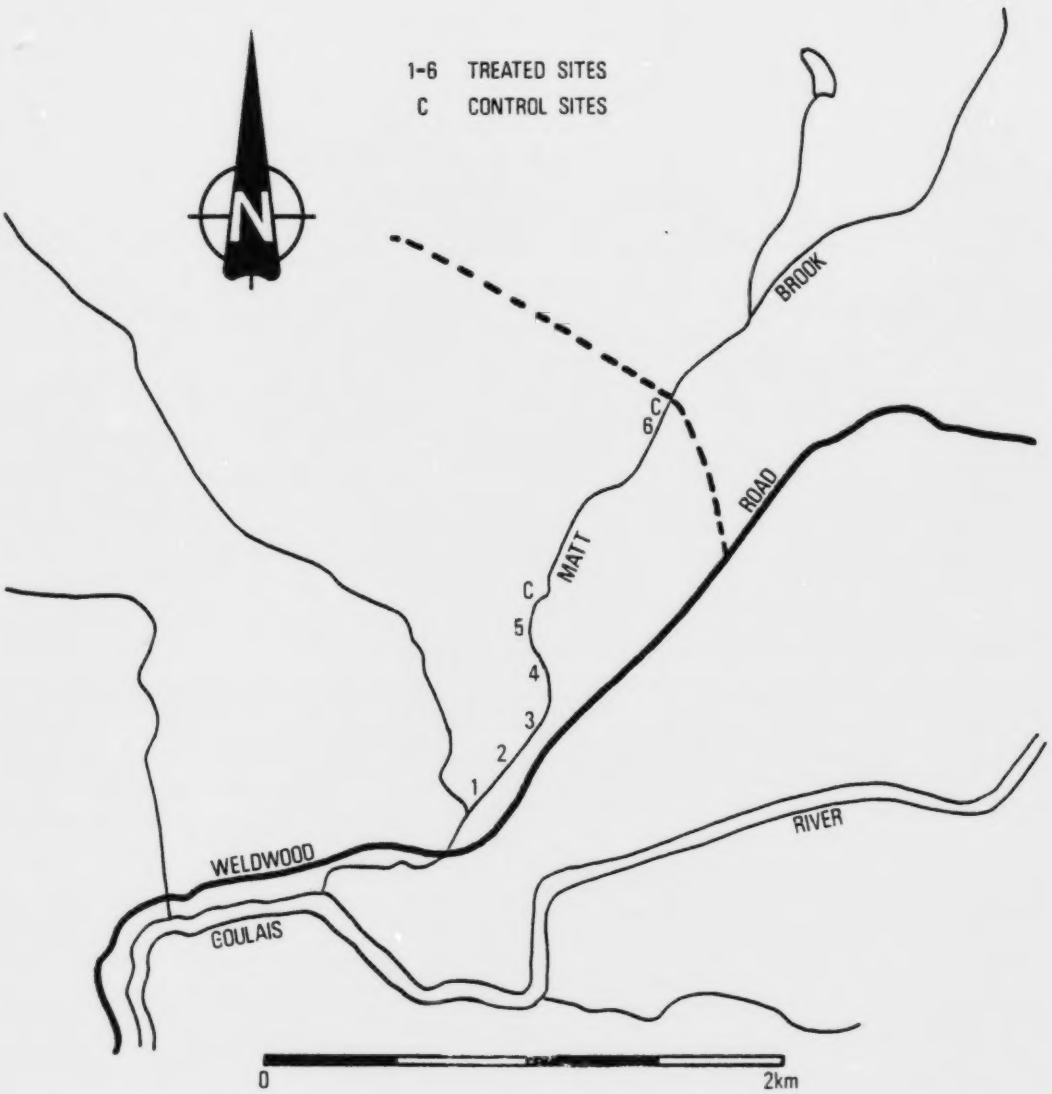


Figure 2. Treated and control sites within Matt Brook.

Figure 3. Application of an aminocarb formulation to Matt Brook using a Micron ULVA sprayer.

Table 2. Application rates of spray formulations used to treat Matt Brook between 4 June and 21 July 1981.

| | Application 1 | Application 2 | Application 3 | Application 4 | Application 5 | Application 6 |
|---|---|---|---|---|---|---|
| Date | 4 June 1981 | 10 June 1981 | 16 June 1981 | 7 July 1981 | 14 July 1981 | 21 July 1981 |
| Time of Application | 0745-0750 EDT | 0800-0805 EDT | 0840-0845 EDT | 0740-0745 EDT | 0755-0800 EDT | 0755-0800 EDT |
| Stream Discharge (L/sec) | 340 | 120 | 320 | 110 | 50 | 10 |
| Emission Rate (ml/min) | 52.0 | 44.0 | 50.0 | 30.0 | 24.0 | 32.0 |
| Calculated Concentration (ppb) Sumspray 7-N (V/V) | 637 | 1528 | | | | |
| Aminocarb (W/V) | | | 156* 29** | 273* | 800* | 3198* |

* calculation based on MATACIL® 1.8D and MATACIL® 1.8F insecticides containing 180 mg AI/ml
** calculation based on actual concentration of active ingredient in faulty MATACIL® 1.8F X sample (33.7 mg AI/ml)

Insecticide Residue Sampling

Aminocarb residues in water, sediment and fish tissue were monitored by the Analytical Chemistry Section of the Forest Pest Management Institute. A complete description of the sampling routine and analytical techniques will be covered in a separate report (Sundaram, in prep.).

Biological Sampling

*Drift*

Aquatic invertebrate drift was monitored at two locations for each application; a treated site approximately 100 m below the application site and a control site 10-250 m above the application site. Drift samples of 10-25 minutes duration were taken at regular intervals at each location (pre-spray, 0, 0.5, 1, 1.5, 2, 3, 4, 5 and 6 hours after application) using a 0.47 m x 0.32 m Wildco drift net[2] with a No. 54 (363μ ) mesh. Additional samples of approximately 24 and 48 hours duration were taken at each site using drift nets fitted with metal restrictors to reduce the size of the opening to 0.48 m x 0.025 m. Drift nets were placed in the stream to sample a column of water from the surface to the bottom including the surface film. Current speed was measured at the opening to each drift net half-way between the surface and bottom using a Teledyne Gurley No. 625 Pygmy Current Meter[3]. Using the above information the following could be calculated:

> depth of water in drift net (m) x width of drift net opening (m) x current speed (m/sec) x duration of drift sample (sec) = $m^3$ of water in drift column.

Drift samples were sorted to remove extraneous material and the organisms collected were preserved in a 70% methanol solution. Organisms were later counted and identified in the laboratory under a 10-60X dissecting microscope and the results expressed as:

> number of aquatic organisms/$m^3$ of water in drift column

*Benthic Invertebrate Populations*

Artificial substrates consisted of 0.5 kg of gravel (12-24 mm screen size) tightly wrapped in seine netting (4 mm x 4 mm aperture size). Samplers were placed in the stream and allowed to colonize for at least 19 days before removal. One day before and 1 day after each application, four artificial substrates and four Surber samples (Surber, 1936) were collected at the treated site. An additional post-spray sample was collected at the treated site 12 days after the sixth application. Samples were also collected periodically at a common control site for the first five

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[2] Wildlife Supply Co,, Saginaw, Michigan
[3] W. & L.E. Gurley Co., Troy, New York

applications and at a separate control site for the sixth application (Fig. 2). After collection aquatic organisms were separated from other materials in the samples and preserved in a 70% methanol solution. Organisms were later counted and identified under a dissecting microscope.

Pre- and post-spray populations were compared with a t-test. A $\log_{10}$ ($x$ + 1) transformation of the data was used to equalize variances (Elliott, 1977) and the significance level was set at $P < 0.05$.

*Caged Fish*

Prior to each insecticide application, three cages, containing approximately 30 rainbow trout fingerlings each, were placed in Matt Brook, two at each treated site and one near the control drift station. Cages measured 61 cm x 61 cm x 46 cm high, had plywood tops and bottoms and were covered on all sides with 13 mm square screening. Fish were obtained from the Ontaro Ministry of Natural Resources, Tarentorous Fish Culture Station in Sault Ste. Marie and were 14-15 months old at the time of the experiment. A random sample of 29 fish on 10 July 1981 had the following measurements ($\bar{x}$ ± S.D.):

| | |
|---|---|
| Total length (mm) | 131.0 ± 18.6 |
| Fork length (mm) | 125.0 ± 18.2 |
| Weight (g) | 21.80 ± 8.81 |

At regular intervals samples of four fish were removed from one of the cages at the treated sites to analyse for insecticide residues. Fish in the other cages were checked periodically up to 3 days after application for mortality.

## RESULTS

### Insecticide Residues

Peak levels of aminocarb in water were detected at the biological sampling stations within 1 hour of the start of each insecticide application (29.2 ppb detected 10 minutes after the MATACIL® 1.8F X + Atlox 3409F + Water treatment, 35.4 ppb detected 15 minutes after the MATACIL® 1.8D + ID 585 treatment, 127.2 ppb detected 30 minutes after the MATACIL® 1.8F + ID 585 treatment and 256.1 ppb detected 60 minutes after the MATACIL® 1.8F + Atlox 3409F + Water treatment) (Fig. 4). Residues were no longer detectable in stream water samples 30 minutes after the MATACIL® 1.8F X + Atlox 3409F + Water treatment and 90 minutes after the MATACIL® 1.8D + ID 585 treatment, but were still present in small amounts (0.1 ppb) 5 hours after the MATACIL® 1.8F + ID 585 treatment and 9 hours after the MATACIL® 1.8F + Atlox 3409F + Water treatment.

Except for the MATACIL® 1.8F X + Atlox 3409F + Water treatment, much higher peak residue levels were measured at the application sites (1862.3 ppb for the MATACIL® 1.8D + ID 585 treatment, 15,000 ppb for the

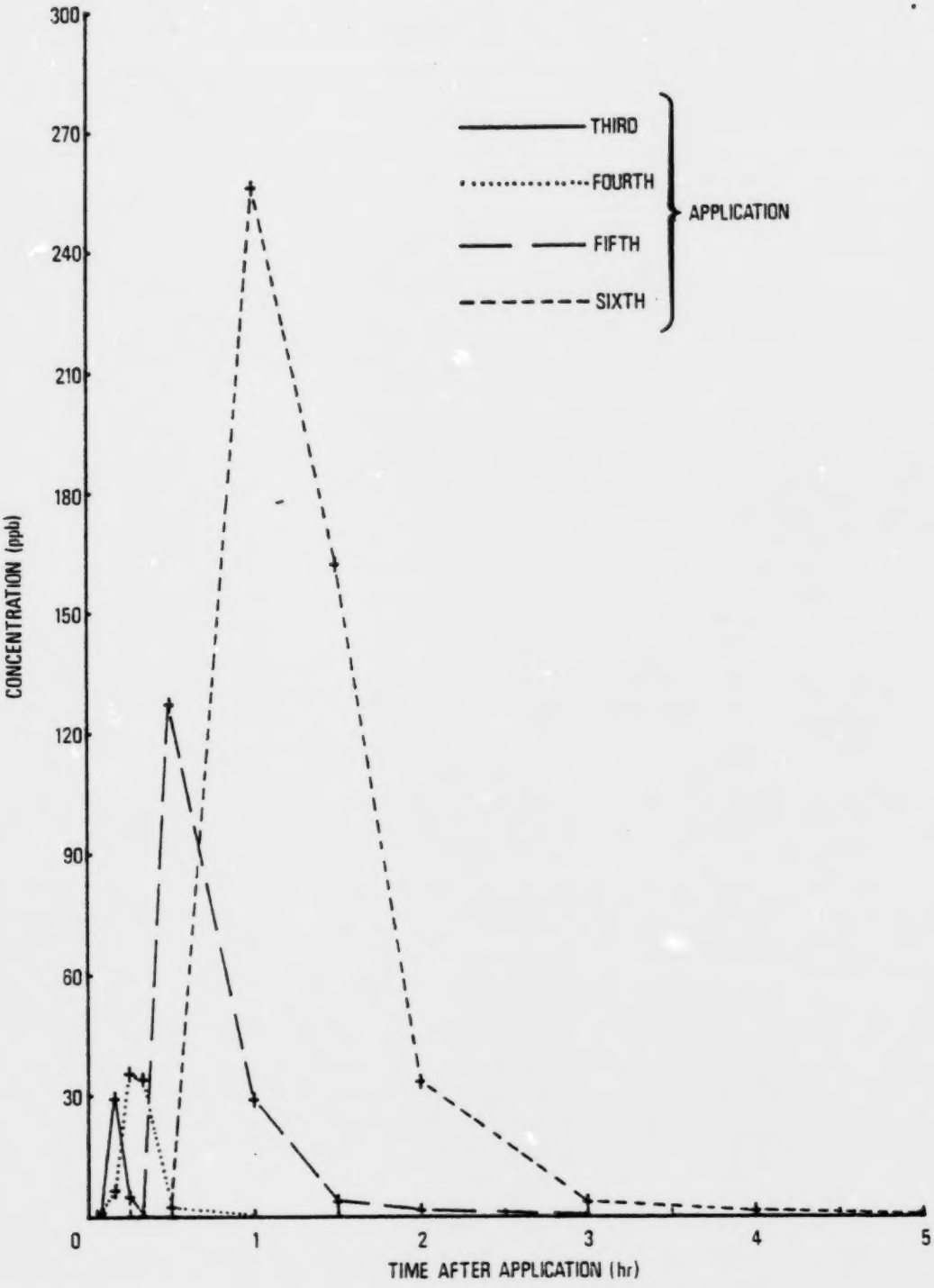


Figure 4. Aminocarb residues in water measured at the biological sampling site after each application of aminocarb formulation to Matt Brook.

MATACIL® 1.8 F + ID 585 treatment and 1306.5 ppb for the MATACIL® 1.8F + Atlox 3409F + Water treatment) (Fig. 5). These samples were taken from the top 1 cm of the stream, approximately 5 m downstream from the application sites. This distance is too short to allow for thorough mixing, and consequently the insecticides were still concentrated at or near the water surface. The insecticide residues would have been more evenly distributed throughout the water column by the time the spray products had been carried 100 m downstream to the biological sampling stations.

The results of analyses of fish samples for aminocarb residues are presented in Table 3. Residues were lowest in fish exposed to the MATACIL® 1.8D + ID 585 treatment, higher in fish exposed to the MATACIL® 1.8F + ID 585 treatment and highest in fish exposed to the MATACIL® 1.8F + Atlox 3409 F + Water treatment. Fish samples from the MATACIL® 1.8F X + Atlox 3409F + Water treatment were not analysed.

Biological Sampling

*Drift*

The results of drift netting are presented in Appendix I, Tables 1-12.

Of the two Sunspray 7-N treatments, only the first appears to have had any significant effect on aquatic invertebrate drift (Fig. 6). Collembola and Leuctridae (Plecoptera) were most affected by the Sunspray 7-N + ID 585 treatment (18 X increase in drift, immediately after application for Collembola and 14 X increase in drift 1 hour after application for Leuctridae) (Appendix I, Table 2). Dytiscidae (Coleoptera) may also have been slightly affected by this treatment. No obvious increases in drift were noted following the Sunspray 7-N + Atlox 3409F + Water application (Appendix I, Table 4).

Two of the four insecticide treatments resulted in substantial increases in aquatic invertebrate drift (Fig. 6) Collembola and Gerridae: Hemiptera both drifted in increased numbers as a result of the MATACIL® 1.8D + ID 585 treatment (> 109 X increase for Collembola and >13 X increase for Gerridae) with the peak of impact occurring immediately after application (Appendix I, Table 8). Hydracarina, Philopotamidae (Trichoptera) and Baetidae (Ephemeroptera) may also have been slightly affected. The MATACIL® 1.8F + Atlox 3409F + Water treatment appears to have had the greatest effect on drift, however. Simuliidae (Diptera), Leuctridae, Baetidae, Philopotamidae and Hydroptilidae (Trichoptera) all drifted in increased numbers as a result of this treatment (> 289 X increase for Simuliidae, >21 X increase for Leuctridae, > 18 X increase for Baetidae, > 7 X increase for Philopotamidae and > 5 X increase for Hydroptilidae) with the peak of impact occurring 1-2 hours after application (Appendix I, Table 12). A number of other taxa, including several families of Trichoptera, may also have been affected by this treatment.

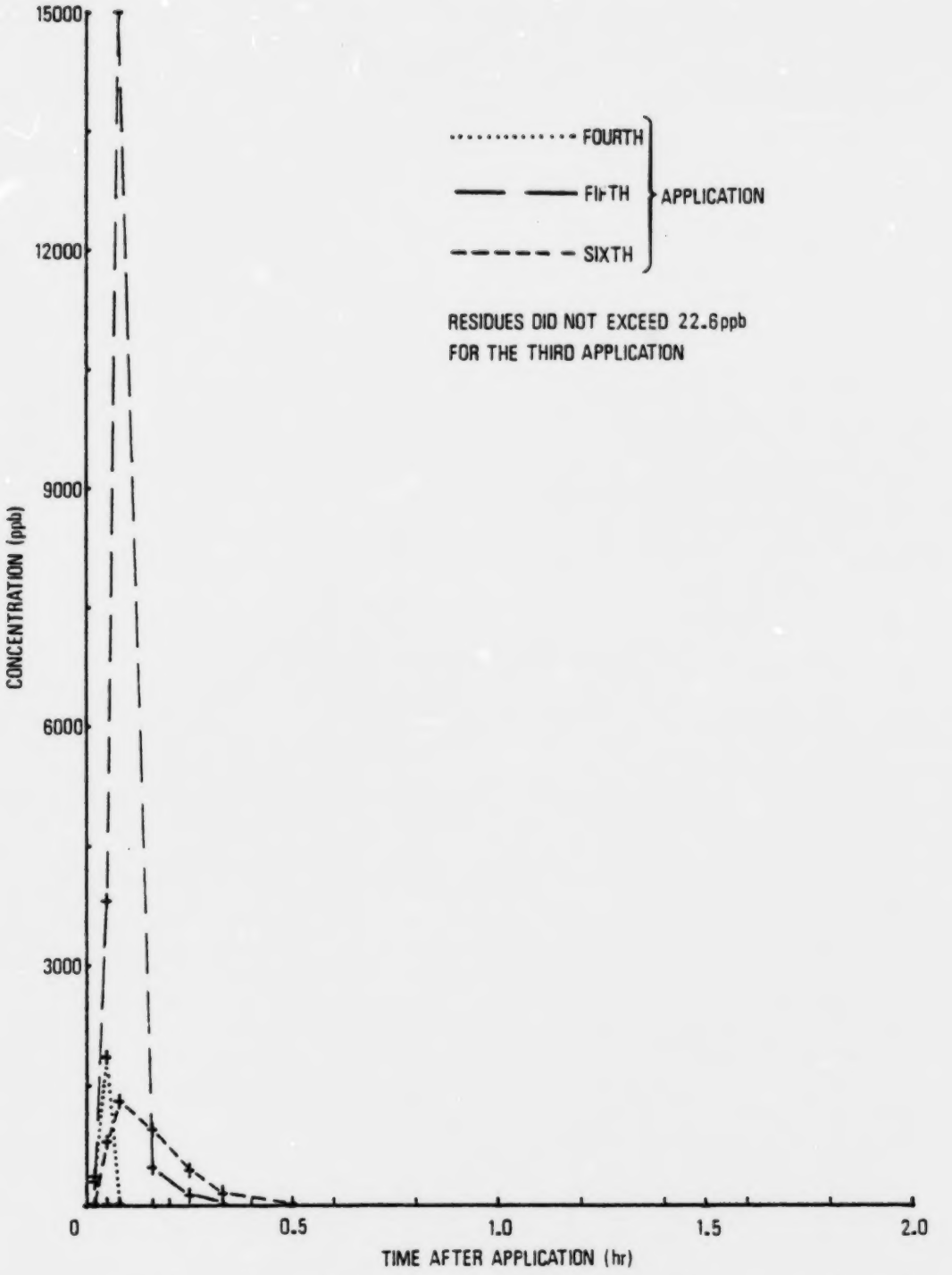


Figure 5. Aminocarb residues in water measured at the application site after each application of aminocarb formulation to Matt Brook.

Table 3. Residues of aminocarb (ppb)* in rainbow trout fingerlings kept in cages in Matt Brook following three aminocarb applications.

| Time after spraying (hr) | MATACIL® 1.8D + ID 585 | MATACIL® 1.8F + ID 585 | MATACIL® 1.8F + Atlox 3409F + Water |
|---|---|---|---|
| Pre-spray | N.D. | N.D. | N.D. |
| 0.5 | 17.1 ± 6.1 | T | N.D. |
| 1.0 | 3.8 ± 2.8 | 4.6 ± 2.9 | 4.4 ± 3.2 |
| 1.5 | T | 18.0 + 4.9 | 85.1 ± 7.9 |
| 2.0 | N.D. | 31.6 ± 6.7 | 106.6 ± 7.4 |
| 3.0 | N.D. | T | 127.4 ± 8.8 |
| 6.0 | N.D. | N.D. | T |

* values are the mean of four determinations
T = Trace (<3.0 ppb based on wet weight of fish)
N.D. = Not detectable (<1.5 ppb based on wet weight of fish)

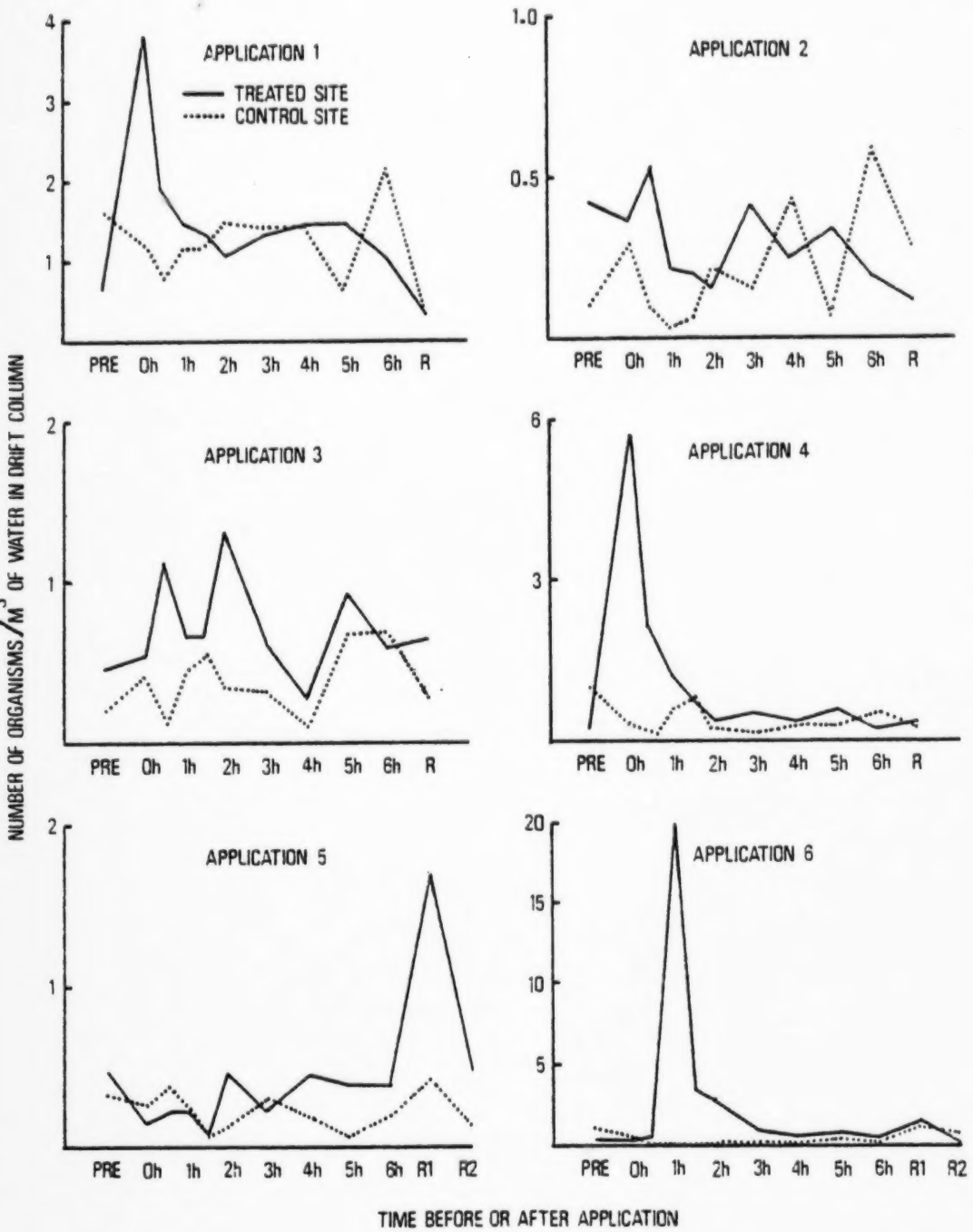
APPLICATION 1
TREATED SITE
CONTROL SITE
APPLICATION 2
APPLICATION 3
APPLICATION 4
APPLICATION 5
APPLICATION 6
PRE 0h 1h 2h 3h 4h 5h 6h R
PRE 0h 1h 2h 3h 4h 5h 6h R1 R2
NUMBER OF ORGANISMS/M3 OF WATER IN DRIFT COLUMN
TIME BEFORE OR AFTER APPLICATION

Figure 6. Aquatic invertebrate drift at treated and control sites following application of various aminocarb formulations to Matt Brook.

Both the MATACIL® 1.8F X + Atlox 3409F + Water and the MATACIL® 1.8F + ID 585 treatments had little, if any, effect on drift (Fig. 6). Increased drifts were noted for Chironomidae (Diptera) following the MATACIL® 1.8F X + Atlox 3409F + Water application (Appendix I, Table 6) and for Collembola, Philopotamidae and Chironomidae following the MATACIL® 1.8F + ID 585 application (Appendix I, Table 10), but these were small and may not have been spray related.

*Benthic Invertebrate Populations*

The results of Surber and artificial substrate sampling are presented in Appendix II, Tables 1-16.

There was a significant reduction in the total number of Diptera collected in Surber samples at the treated site 1 day after the Sunspray 7-N + ID 585 treatment (Appendix II, Table 3). Only Chironomidae pupae were reduced significantly, although a number of other groups, including Chironomidae and Tabanidae larvae, also declined. Limnephilidae (Trichoptera) also decreased in numbers in the post-spray sample at the treated site, but not significantly. At the control site, total Diptera and Chironomidae increased in abundance in Surber samples (Appendix II, Table 1). As at the treated site, Tabanidae numbers decreased. Limnephilidae were not present at the control site. No reductions were evident in artificial substrate samples following treatment (Appendix II, Table 4). An increase in the number of Chironomidae in post-spray samples from the treated site was not significant.

No significant reductions in numbers occurred in any taxa in Surber samples from the Sunspray 7-N + Atlox 3409 F + Water treated site (Appendix II, Table 5). Although the total number of Ephemeroptera in artificial substrates was significantly reduced following treatment, when taken separately, reductions of Baetidae and Ephemerelidae were not significant (Appendix II, Table 6). Total Ephemeroptera, Baetidae and Ephemerellidae were also reduced at the control site at this time (Appendix II Table 2).

There were no significant reductions in numbers in any taxa in Surber and artifical substrate samples taken from the treated site 1 day after the MATACIL® 1.8F X + Atlox 3409F + Water application (Appendix II, Tables 7 and 8). Hydracarina increased significantly in abundance in postspray samples of artificial substrates from both the treated and control sites (Appendix II, Tables 2 and 8). Very few invertebrates were collected in Surber samples at the control site on 17 June as a result of sampling error.

Total Plecoptera, Ephemeroptera and Diptera were all significantly reduced in numbers in artificial substrates 1 day after the MATACIL® 1.8D + ID 585 treatment (Appendix II, Table 10). Although all three families of Plecoptera represented were reduced, none of these reductions were significant. Taeniopterygidae, but not Leuctridae or Chloroperlidae, were also reduced at the control site. Within the Ephemeroptera, Baetidae and

Ephemerellidae were both reduced at the treated site, with Ephemerellidae being reduced significantly. Ephemerellidae were also reduced at the control site, but not Baetidae. Chironomidae were significantly reduced in numbers at both the treated and control sites. No significant reductions occurred in any taxa in Surber samples from the treated site (Appendix II, Table 9).

Surber and artificial substrate sampling revealed no significant reductions in any taxa following the MATACIL® 1.8F + ID 585 treatment (Appendix II, Tables 11 and 12). Hydracarina, Leuctridae and Chironomidae all significantly increased in abundance in artificial substrates. Leuctridae also increased in abundance at the control site, but Hydracarina and Heleidae (Diptera) were both reduced in numbers, with Hydracarina being reduced significantly (Appendix II, Table 2).

Simuliidae larvae were eliminated from Surber samples at the treated site 1 day after the MATACIL® 1.8F + Atlox 3409F + Water application and were still absent 11 days later (Appendix II, Table 15). Although Chironomidae larvae were also reduced in numbers in post-spray Surber samples from the treated site, a similar trend was noted at the control site (Appendix II, Table 13). There were no significant reductions in numbers in any taxa in artificial substrate samples taken from the treated site 1 day after application (Appendix II, Table 16). Chironomidae larvae were significantly reduced in numbers by the time of the second post-spray sample. Most other taxa had increased in abundance by this time.

*Caged Fish*

No mortality was noted among fish held in cages at any of the treated or control sites.

## DISCUSSION

Although the aim of this experiment was to compare the effects of formulation on the toxicity of MATACIL® insecticide to aquatic organisms, unfortunately this type of direct comparison was not possible because the dosage rate was different for each of the field formulations tested. Unforeseen delays caused by the weather, nuisance beavers and a faulty insecticide sample resulted in the program being prolonged into that part of the summer when water levels began to drop very rapidly. This meant that the dosage rate was lowest for the first insecticide application when stream discharge was highest, and progressively higher for each application that followed as stream discharge dropped. In addition as discharge decreased the amount of time it took for the insecticide residues to move downstream and disappear increased. Consequently aquatic organisms were exposed to higher levels of aminocarb for longer periods of time following each subsequent application. In future programs these problems could be overcome in two ways:

1) by confining testing to that part of the season when water levels are relatively stable (i.e., after spring flooding has subsided and before the advent of low summer levels). This means that all applications would have to be completed within a fairly short (4-5 week) period of time.

2) by changing the application system. A Micron 'ULVA' Sprayer was used to dose the stream in the present study because we believed that this type of application would most closely imitate the deposit resulting from an aerial application of insecticide. This system does have a disadvantage however, in that it is not possible to vary the emission rate of the sprayer to compensate for changes in stream discharge. A new piece of equipment should be designed which combines both of these desirable qualities.

Except for the MATACIL® 1.8F X + Atlox 3049F + Water treatment, peak levels of aminocarb in water at the biological sampling stations following application were much lower than 'expected' (13% of the calculated concentration for the MATACIL® 1.8D + ID 585 treatment, 16% for the MATACIL® 1.8F + ID 585 treatment and 8% for the MATACIL® 1.8F + Atlox 3409 F + Water treatment). The greatest part of this difference can be explained in two ways:

1) Some of the very fine droplets produced by the Micron ULVA Sprayer were either carried away by the wind or impinged on overhanging vegetation and thus never entered the stream.

2) In the calculation of 'expected' concentrations it was assumed that the insecticide moved downstream as a fairly discreet slug of constant concentration whereas in actual fact this was not the case. The presence of slow or dead water areas in the treated sections of stream tended to prolong the downstream passage of the insecticide slugs which were diluted by uncontaminated water from above the application sites. A somewhat different situation existed for the MATACIL® 1.8F X + Atlox 3409F + Water treatment, however. Stream discharge at the time of this application was extremely high as a result of heavy rains the night before. Consequently there were few if any areas of slow flow and the insecticide was flushed downstream very rapidly.

Other factors such as migration of residues into the sediments, uptake and metabolism by aquatic plants and animals and chemical and photolytic breakdown would also have played a role in reducing aminocarb concentrations in the 100 m between the application and biological sampling sites.

In the past, few monitoring programs have been conducted in which the concentration of aminocarb in water was known. Coady (1978) studied the effects of the 1977 Newfoundland experimental budworm spray and found aminocarb levels in streams as high as 24 pb within several hours of spraying with MATACIL® at a dosage rate of 90 g AI/ha. Stream invertebrate

populations and drift activity were apparently unaffected. During the 1978 Newfoundland operational budworm spray, aminocarb levels in one of the two streams monitored rose to a peak of 34 ppb after spraying with MATACIL® at a dosage rate of 70 g AI/ha (Environmental Monitoring Committee, 1979). Far lower levels were encountered in the other stream. Although there was an immediate increase in the numer of terrestrial and aquatic insects in drift samples after spraying, benthic invertebrate populations were not reduced. Holmes (1979) monitored aquatic invertebrates in several streams sprayed with MATACIL® at a dosage rate of 53 g AI/ha during the 1978 Quebec spruce budworm control program. A peak aminocarb level of 3.34 ppb in one stream, the highest level of aminocarb recorded in any of the streams studied, was associated with a small increase in the number of drifting Simuliidae larvae. Impacts on a number of aquatic invertebrate groups were indicated, either by increases in drift activity or reductions in bottom fauna populations, following an experimental MATACIL® application at the seasonal maximum allowable dosage rate of 175 g AI/ha in Quebec in 1979 (Holmes and Kingsbury, 1980). Two streams were monitored for aminocarb residues in this study and had peak levels of 13.7 ppb and 24.2 ppb shortly after spraying.

In the present study only two of the four insecticide treatments (MATACIL® 1.8D + ID 585 and MATACIL® 1.8F + Atlox 3409F + Water) appeared to have any measurable effect on aquatic invertebrates. The peak level of aminocarb in water following the MATACIL® 1.8D + ID 585 treatment (35.4 ppb) was higher than any of the peak levels noted previously for operational and experimental aerial applications of MATACIL® in Newfoundland and Quebec. Residue levels were even higher following the MATACIL® 1.8F + Atlox 3409F + Water treatment (256.1 ppb). Drift activity and benthic invertebrate populations were apparently unaffected by both the MATACIL® 1.8F X + Atlox 3409F + Water treatment, where peak levels of aminocarb reached 29.2 ppb (which is close to the maximum concentration measured in operational spray program), and the MATACIL® 1.8F + ID 585 treatment, where the peak level was 127.2 ppb.

Eidt (1979) attempted to determine the concentration of aminocarb that would kill benthos by injecting MATACIL® into a stream and monitoring drift and mortality of caged insects. None of his field treatments (4.7 ppb for 1 h 30 min followed by 13.7 ppb for 1 h and 2.48 ppb for 2 h 30 min followed by 15.84 ppb for 2 h 15 min) had any observable effects on aquatic invertebrates, however, and he recommended that further field experiments be conducted to determine the lethal dose. From the present study, it would appear that the minimum concentration required to kill stream invertebrates is different for different MATACIL® field formulations ( <35.4 ppb active ingredient for MATACIL® 1.8D + ID 585 and >127.2 ppb active ingredient for MATACIL® 1.8F + ID 585).

Recently there has been increasing attention focused on the contribution of so-called 'inert ingredients' to the toxicity of insecticide formulations (McLeese et al., 1980a and b). Although most of the

research has been confined to the laboratory, Holmes and Kingsbury (1980) conducted a field experiment to determine whether nonyl phenol, a component of the MATACIL® 1.8D formulation, was toxic to aquatic organisms at concentrations likely to be encountered under operational spray conditions. In the present study, two Sunspray 7-N treatments (Sunspray 7-N is present as a primary solvent in the new MATACIL® 1.8F formulation) were conducted with a similar objective in mind. One of these, the Sunspray 7-N + ID 585 treatment, did have an effect on aquatic invertebrates, but the other, the Sunspray 7-N + Atlox 3409F + Water treatment, did not. Since the dosage rate was almost 2.4 times higher for the Sunspray 7-N + Atlox 3409F + Water treatment as for the Sunspray 7-N + ID 585 treatment, it would seem that the toxicity of Sunspray 7-N may not have been the only factor contributing to the observed impact. Some other possibilities are:

1) that the tendency of the Sunspray 7-N + ID 585 formulation to remain on the surface of the stream as an 'oil slick' may have increased the exposure of surface dwelling organisms such as Collembola

2) that the 'oil slick' may have physically trapped organisms on the surface

3) that ID 585 may be toxic to certain aquatic organisms.

In general, peak levels and persistence of aminocarb residues in fish appeared to be correlated with peak levels and persistence of residues in stream water. Bioaccumulation ratios (peak concentration in fish/peak concentration in water) were 0.48 for the MATACIL® 1.8D + ID 585 treatment, 0.25 for the MATACIL® 1.8F + ID 585 treatment and 0.50 for the MATACIL® 1.8F + Atlox 3409F + Water treatment. Szeto and Holmes (1982) reported much higher bioaccumulation ratios ranging from 1.70 to 3.32 for rainbow trout fingerlings exposed to different concentrations of aminocarb in an acute toxicity test. This difference can be explained by the fact that in the laboratory experiment fish were exposed to a constant concentration of aminocarb for 96 hours, whereas in the field experiment aminocarb concentrations rose to a peak and then declined.

## CONCLUSIONS

Because of the differing dosage rates it is not possible to make a direct comparison of the old and new MATACIL® formulations. Nevertheless the new MATACIL® 1.8F flowable formulation does not appear to pose a significantly greater hazard to the aquatic environment than the MATACIL® 1.8D formulation which is currently used for spruce budworm control in eastern Canada.

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## APPENDIX I

Aquatic invertebrate drift data from treated and control sites in Matt Brook for each aminocarb formulation application.

## Table 1.

Aquatic invertebrates collected in drift net sets,*
First Application, Control Site,
4-5 June 1981.

| Sample | | Pre | 0 | +½h | +1h | +1½h | +2h | +3h | +4h | +5h | +6h | RES |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Volume of drift column ($m^3$) | | 43.1 | 43.1 | 41.7 | 41.7 | 41.7 | 41.7 | 40.3 | 26.8 | 25.4 | 25.9 | 190.6 |
| Nematomorpha | | 0.02 | | | 0.07 | 0.02 | 0.05 | | | 0.08 | 0.08 | |
| Annelida: Oligochaeta | | 0.02 | | | | | | | | 0.04 | | 0.01 |
| Ostracoda | | 0.26 | 0.02 | 0.12 | 0.12 | 0.14 | 0.34 | 0.17 | 0.26 | 0.08 | 0.23 | |
| Hydracarina | | 0.26 | 0.23 | 0.10 | 0.24 | 0.14 | 0.14 | 0.12 | 0.07 | | 0.35 | 0.01 |
| Collembola | | 0.02 | | | | | | 0.02 | 0.04 | | 0.08 | 0.04 |
| Plecoptera: Chloroperlidae | N | | | 0.02 | | | | | | | | 0.01 |
| Leuctridae | N | 0.02 | 0.02 | | | | | | | | | 0.01 |
| Perlodidae | N | | | | | | | | | | | 0.01 |
| Ephemeroptera: Baetidae | N | | | | 0.02 | | 0.05 | | | | 0.12 | 0.01 |
| Leptophlebiidae | N | | | | | | | | | | | 0.01 |
| Trichoptera: Hydropsychidae | L | 0.02 | | | 0.02 | | 0.02 | | | | | |
| Hydroptilidae | L | 0.14 | 0.12 | 0.05 | 0.14 | 0.14 | 0.02 | 0.22 | 0.15 | | 0.08 | |
| Lepidostomatidae | L | 0.02 | 0.02 | 0.02 | 0.05 | 0.02 | 0.02 | 0.02 | | | 0.04 | 0.01 |
| Limnephilidae | L | 0.05 | 0.09 | 0.02 | 0.10 | 0.10 | 0.12 | 0.17 | 0.04 | | 0.15 | 0.01 |
| Psychomyiidae | L | | | 0.02 | | | | | | | | |
| Rhyacophilidae | L | | 0.05 | | | 0.02 | | | 0.02 | 0.04 | 0.04 | |
| Unidentified | L | | | | | | | | 0.04 | | | |
| Coleoptera: Elmidae | L | | | | | | 0.02 | | | | | |
| Curculionidae | A | | | | | | 0.02 | | | | | |
| Diptera: Chironomidae | L | 0.49 | 0.30 | 0.31 | 0.24 | 0.22 | 0.29 | 0.42 | 0.22 | 0.23 | 0.39 | 0.14 |
| | P | 0.14 | 0.30 | 0.19 | 0.07 | 0.19 | 0.31 | 0.15 | 0.45 | 0.08 | 0.42 | 0.02 |
| Dolichopodidae | L | | 0.02 | | | | | | | | | |
| Empididae | L | | | | 0.02 | 0.02 | | | 0.04 | | | |
| Heleidae | L | 0.02 | 0.02 | 0.02 | | 0.07 | | | | | 0.04 | |
| | P | 0.07 | 0.02 | | | 0.05 | 0.02 | 0.02 | 0.04 | 0.04 | 0.08 | 0.02 |
| Simuliidae | L | 0.02 | | | | 0.05 | 0.07 | 0.05 | 0.04 | 0.04 | 0.04 | 0.01 |
| Tipulidae | L | | | 0.02 | | | | | | | | |
| | P | | | | 0.02 | | | | | | | 0.01 |
| Gastropoda | | 0.02 | | | | | | | | | | |
| Total | | 1.60 | 1.23 | 0.91 | 1.15 | 1.17 | 1.51 | 1.41 | 1.42 | 0.61 | 2.12 | 0.28 |

* Expressed as number of organisms/$m^3$ of water in drift column.
RES restrictor drift left overnight, 4-5 June 1981.
L larvae
P pupae
N nymphs
A adults

## Table 2.

Aquatic invertebrates collected in drift net sets,*
First Application, Treated Site**,
4-5 June 1981.

| Sample | | Pre | 0 | +½h | +1h | +1½h | +2h | +3h | +4h | +5h | +6h | RES |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Volume of drift column ($m^3$) | | 60.1 | 60.1 | 60.1 | 60.1 | 60.1 | 60.1 | 60.1 | 40.1 | 40.1 | 40.1 | 289.6 |
| Nematomorpha | | 0.03 | | 0.02 | 0.03 | | 0.03 | 0.02 | | | 0.02 | 0.01 |
| Annelida: Oligochaeta | | 0.03 | 0.03 | | 0.02 | | 0.02 | 0.03 | 0.02 | 0.02 | 0.02 | 0.01 |
| Ostracoda | | 0.08 | | | 0.02 | | 0.02 | 0.05 | | | 0.02 | 0.01 |
| Hydracarina | | 0.18 | 0.17 | 0.15 | 0.07 | 0.02 | 0.12 | 0.15 | 0.22 | 0.17 | 0.20 | 0.01 |
| Collembola | | 0.12 | 2.26 | 0.28 | 0.25 | 0.18 | 0.08 | 0.22 | 0.15 | 0.45 | 0.10 | 0.05 |
| Plecoptera: Leuctridae | N | 0.03 | 0.07 | 0.27 | 0.42 | 0.32 | 0.22 | 0.27 | 0.12 | 0.17 | 0.07 | 0.04 |
| Taeniopterygidae | N | | 0.02 | | | | | | | | | |
| Ephemeroptera: Baetidae | N | | 0.07 | 0.07 | | 0.02 | | | | | | 0.02 |
| Ephemerellidae | N | | | | | | | | | | | 0.01 |
| Leptophlebiidae | N | 0.03 | | 0.02 | | | | | | | | |
| Hemiptera: Gerridae | | | | | | | | 0.02 | | | | |
| Trichoptera: Brachycentridae | L | | 0.02 | | | | | | | | | |
| Hydropsychidae | L | | | | | 0.02 | | 0.02 | | | | |
| Hydroptilidae | L | 0.08 | 0.13 | 0.27 | 0.02 | 0.02 | 0.15 | 0.08 | 0.10 | 0.10 | 0.05 | 0.01 |
| Limnephilidae | L | 0.03 | 0.07 | 0.15 | 0.15 | 0.10 | 0.03 | 0.05 | 0.07 | 0.07 | | 0.01 |
| Lepidostomatidae | L | 0.05 | 0.02 | 0.02 | 0.02 | 0.03 | | 0.03 | | | 0.05 | |
| Psychomyiidae | L | | | | 0.02 | | | | | | | |
| Rhyacophilidae | L | | | | | | | | 0.02 | | | |
| Unidentified | L | 0.02 | | | | | | | | | | |
| Coleoptera: Dytiscidae | L | | 0.03 | 0.10 | | 0.03 | 0.02 | | 0.02 | | | 0.01 |
| | A | | | | | | | | | | 0.02 | 0.01 |
| Elmidae | A | | 0.02 | | | 0.02 | | | | | | |
| Gyrinidae | A | | | | | | 0.02 | | | | | |
| Haliplidae | A | | | | | | | | | | 0.02 | |
| Helodidae | L | | | 0.03 | | 0.03 | | | 0.02 | | 0.02 | |
| | A | | | | | | | | | | | |
| Hydraenidae | L | | 0.02 | | | | | | | | | 0.01 |
| | A | | | | | | | 0.02 | | | | |
| Noteridae | A | | 0.02 | | | | | | | | | |
| Diptera: Chironomidae | L | 0.17 | 0.28 | 0.10 | 0.20 | 0.30 | 0.25 | 0.13 | 0.30 | 0.05 | 0.15 | 0.04 |
| | P | 0.13 | 0.35 | 0.23 | 0.15 | 0.13 | 0.08 | 0.12 | 0.17 | 0.30 | 0.15 | 0.03 |
| Dixidae | L | 0.02 | 0.02 | 0.02 | | | | | | | | |
| Empididae | L | 0.02 | 0.03 | 0.02 | | 0.02 | | | | | | 0.01 |
| | P | | | | | 0.02 | | 0.02 | | | | |
| Heleidae | L | 0.07 | 0.02 | 0.03 | | 0.02 | | 0.02 | | | | |
| | P | | 0.08 | 0.07 | | 0.02 | 0.02 | 0.03 | 0.02 | 0.02 | | 0.03 |
| Muscidae | L | | | | | 0.02 | | 0.02 | | | | |
| Simuliidae | L | 0.02 | 0.07 | 0.03 | 0.03 | | | | | | 0.07 | 0.02 |
| | P | 0.02 | 0.02 | | | | | | | 0.02 | | |
| Tabanidae | P | | | | | | | | 0.02 | | | |
| Tipulidae | L | | 0.02 | 0.02 | | | | | 0.05 | | | |
| | P | 0.02 | | | 0.08 | 0.02 | | 0.02 | 0.05 | 0.05 | 0.02 | 0.03 |
| Total | | 1.15 | 3.31 | 1.88 | 1.46 | 1.31 | 1.05 | 1.30 | 1.45 | 1.45 | 1.02 | 0.31 |

* Expressed as number of organisms/$m^3$ of water in drift column.
** Sunspray 7-N + Automate Red Dye + Insecticide Diluent 585 applied at 0745-0750 EDT on 4 June 1981.
RES restrictor drift left overnight, 4-5 June 1981.
L larvae
P pupae
N nymphs
A adults

Table 3.

Aquatic invertebrates collected in drift net sets,*
Second Application, Control Site,
10-11 June 1981.

| Sample | | Pre | 0 | +½h | +1h | +1½h | +2h | +3h | +4h | +5h | +6h | RES |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Volume of drift column ($m^3$) | | 29.9 | 30.8 | 31.6 | 30.8 | 31.6 | 31.6 | 32.4 | 31.6 | 32.4 | 32.4 | 221.7 |
| Ostracoda | | | | | | | | | 0.03 | 0.03 | | |
| Hydracarina | | 0.03 | 0.19 | | | 0.03 | 0.06 | 0.03 | 0.16 | | 0.25 | |
| Collembola | | 0.03 | | | | | | | 0.03 | | 0.09 | 0.04 |
| Plecoptera: Chloroperlidae | N | | | | | | | | | | | 0.01 |
| Leuctridae | N | | | | | | | 0.03 | | | | 0.03 |
| Ephemeroptera: Baetidae | N | | | | | | 0.03 | | 0.03 | | | 0.01 |
| Hemiptera | N | | | | | | 0.03 | | | | | |
| Trichoptera: Hydropsychidae | L | | | | | | | | | | | 0.01 |
| Hydroptilidae | L | | | | | | | | 0.06 | | 0.06 | 0.01 |
| Lepidostomatidae | L | | | | | | | | | | 0.03 | |
| Limnephilidae | L | 0.03 | | | | 0.03 | | 0.03 | | | | |
| Psychomyiidae | L | | | | | | | | | | | 0.01 |
| Coleoptera: Elmidae | A | | | | 0.03 | | | | | | | |
| Helodidae | A | | | 0.03 | | | | | | | | |
| Diptera: Chironomidae | L | | 0.03 | 0.03 | | | 0.09 | | 0.06 | 0.03 | 0.06 | 0.15 |
| | P | | 0.03 | | | | | | 0.03 | | 0.06 | 0.01 |
| Heleidae | P | | | | | | 0.03 | | | | 0.03 | |
| Simuliidae | L | | 0.03 | 0.03 | | | | 0.06 | | | | 0.02 |
| Tipulidae | L | | | | | | | | 0.03 | | | 0.01 |
| Total | | 0.10 | 0.29 | 0.09 | 0.03 | 0.06 | 0.22 | 0.15 | 0.44 | 0.06 | 0.59 | 0.29 |

* Expressed as number of organisms/$m^3$ of water in drift column.
RES restrictor drift left overnight, 10-11 June 1981.
L larvae
P pupae
N nymphs
A adults

Table 4.

Aquatic invertebrates collected in drift net sets*
Second Application, Treated Site**,
10-11 June 1981.

| Sample | | Pre | 0 | +½h | +1h | +1½h | +2h | +3h | +4h | +5h | +6h | RES |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Volume of drift column ($m^3$) | | 19.2 | 29.6 | 20.2 | 19.2 | 19.7 | 19.7 | 19.7 | 19.7 | 20.7 | 20.7 | 180.4 |
| Nematomorpha | | | 0.03 | | | | 0.05 | | | | | 0.01 |
| Annelida: Oligochaeta | | | 0.03 | | | | | | | 0.05 | | 0.01 |
| Ostracoda | | 0.05 | 0.10 | 0.05 | 0.05 | 0.05 | | 0.10 | | 0.10 | | 0.01 |
| Hydracarina | | 0.05 | | 0.05 | | | | | | 0.05 | | |
| Collembola | | 0.05 | | | | | | 0.05 | | | 0.05 | 0.01 |
| Plecoptera: Leuctridae | N | | | | | | 0.05 | 0.10 | | | | 0.01 |
| Ephemeroptera: Baetidae | N | | | 0.05 | | | | | | | | 0.01 |
| Ephemerellidae | N | | | | | | | | | | | |
| Trichoptera: Hydropsychidae | L | | | | 0.05 | 0.05 | | | | | 0.05 | |
| Hydroptilidae | L | | 0.07 | | | | | | | | | |
| Lepidostomatidae | L | 0.10 | 0.10 | 0.10 | 0.05 | | | 0.10 | 0.15 | | | 0.03 |
| Diptera: Chironomidae | P | 0.05 | | 0.20 | 0.05 | 0.05 | | 0.05 | 0.10 | 0.05 | | |
| Empididae | L | | | | | | | | | | 0.05 | |
| Heleidae | P | | | | | 0.05 | | | | | 0.05 | |
| Simuliidae | L | 0.10 | 0.03 | 0.10 | | | | | | 0.10 | | 0.03 |
| Tipulidae | L | | | | | | | | | | | 0.01 |
| | P | | | | | | 0.05 | | | | | |
| Total | | 0.42 | 0.37 | 0.54 | 0.21 | 0.20 | 0.15 | 0.41 | 0.25 | 0.34 | 0.19 | 0.12 |

* Expressed as number of organisms/$m^3$ of water in drift column.
** Sunspray 7-N + Atlox 3409 F + Rhodamine B Dye + Water applied at 0800-0805 EDT on 10 June 1981.
RES restrictor drift left overnight, 10-11 June 1981.
L larvae
P pupae
N nymphs
A adults

Table 5.

Aquatic invertebrates collected in drift net sets*,
Third Application, Control Site**,
16-17 June 1981.

| Sample | | Pre | 0 | +½h | +1h | +1½h | +2h | +3h | +4h | +5h | +6h | RES |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Volume of drift column ($m^3$) | | 37.4 | 36.7 | 37.4 | 36.7 | 35.9 | 35.9 | 36.7 | 35.9 | 35.2 | 34.5 | 209.7 |
| Annellida: Oligochaeta | | | | | | | 0.03 | | | | | <0.01 |
| Ostracoda | | | | | | 0.03 | 0.06 | | | 0.06 | | 0.03 |
| Hydracarina | | | | | | | | | | | | |
| Plecoptera: Leuctridae | N | | 0.03 | | 0.03 | 0.03 | | | | 0.11 | | 0.04 |
| Ephemeroptera: Baetidae | N | | | | | | 0.03 | | | 0.06 | | |
| Odonata: Aeshnidae | N | | 0.03 | | 0.03 | 0.03 | | | | 0.09 | 0.03 | <0.01 |
| Hemiptera: Gerridae | | | | | | | | | | 0.03 | | |
| Trichoptera: Hydroptilidae | L | | | | | 0.03 | | | 0.03 | | 0.03 | |
| Lepidostomatidae | L | | | | | 0.03 | | | | | | |
| Limnephilidae | L | | | | | | 0.03 | | | | | |
| Philopotamidae | L | | | | | 0.03 | | | | 0.03 | | |
| Rhyacophilidae | L | | | | | | | | | | | |
| Unidentified | P | | 0.03 | | | | | | | | | <0.01 |
| Coleoptera: Dytiscidae | L | | | | | 0.03 | 0.03 | | | | | |
| Haliplidae | L | | | | 0.03 | 0.06 | | | | | | |
| Staphylinidae | A | | | | 0.11 | 0.08 | 0.03 | 0.19 | 0.03 | 0.06 | 0.17 | <0.01 |
| Diptera: Chironomidae | L | 0.08 | 0.08 | | 0.05 | 0.14 | 0.06 | 0.05 | 0.03 | 0.03 | 0.14 | 0.04 |
| | P | 0.08 | 0.22 | 0.08 | 0.08 | | 0.03 | | | 0.11 | 0.26 | 0.02 |
| Empididae | L | | | | | 0.03 | | | | | 0.03 | |
| Heleidae | L | | | 0.03 | | | | | | | | |
| | P | 0.05 | 0.03 | 0.03 | 0.11 | | 0.08 | 0.05 | 0.03 | 0.09 | 0.03 | 0.04 |
| Simulidae | L | | 0.03 | | | 0.06 | | 0.03 | | 0.03 | | 0.07 |
| Tipulidae | L | | | 0.03 | | | | | | | | 0.01 |
| Total | | 0.21 | 0.44 | 0.13 | 0.46 | 0.56 | 0.36 | 0.33 | 0.11 | 0.68 | 0.70 | 0.28 |

* expressed as number of organisms/$m^3$ of water in drift column.
RES restrictor drift left overnight, 16-17 June 1981.
L larvae
P pupae
N nymphs
A adults

# Table 6.

Aquatic invertebrates collected in drift net sets*, Third Application, Treated Site**, 16-17 June 1981.

| Sample | | Pre | 0 | +½h | +1h | +1½h | +2h | +3h | +4h | +5h | +6h | RES |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Volume of drift column ($m^3$) | | 15.5 | 23.6 | 15.2 | 15.2 | 15.2 | 15.2 | 14.7 | 15.2 | 14.7 | 14.7 | 108.6 |
| Nematomorpha | | | | | | | 0.07 | | | | | 0.01 |
| Annelida: Oligochaeta | | | | | | | | | | | | 0.02 |
| Hydracarina | | | | | | | 0.07 | | 0.07 | | | 0.01 |
| Plecoptera: Leuctridae | N | | | | | | | 0.07 | | | 0.07 | 0.09 |
| Taeniopterygidae | N | | | 0.07 | | | | | | | 0.07 | |
| Ephemeroptera: Baetidae | N | 0.06 | 0.13 | | | | 0.07 | | | 0.07 | | |
| Odonata: Aeshnidae | N | | | | | | | | | | | 0.01 |
| Trichoptera: Hydropsychidae | L | | | 0.13 | | 0.20 | 0.07 | | | | | 0.01 |
| Hydroptilidae | L | | | | | | | | | | | |
| Lepidostomatidae | L | 0.13 | | | | | 0.07 | 0.07 | | 0.07 | 0.07 | |
| Limnephilidae | L | | | | | 0.07 | | | 0.07 | | | 0.01 |
| Psychomyiidae | L | | | | | | | | | | | |
| Coleoptera: Dytiscidae | L | | | | | | | | | | | |
| Staphylinidae | A | | 0.04 | 0.20 | 0.20 | 0.26 | 0.59 | 0.34 | 0.13 | 0.68 | 0.14 | 0.33 |
| Diptera: Chironomidae | L | 0.06 | 0.13 | 0.26 | 0.07 | 0.07 | 0.26 | 0.07 | | | 0.14 | 0.06 |
| | P | 0.06 | 0.13 | 0.20 | 0.13 | | 0.07 | | | | | |
| Dolichopodidae | L | 0.06 | | | | | | | | | | |
| Empididae | L | | 0.04 | | | | | | | | | 0.01 |
| Heleidae | L | 0.06 | | | | | | | | 0.07 | 0.14 | |
| | P | | 0.08 | 0.07 | 0.07 | | 0.07 | | | 0.07 | | 0.06 |
| Simuliidae | L | | | 0.07 | 0.13 | 0.07 | | 0.07 | | | | 0.02 |
| Tipulidae | L | | | 0.13 | 0.07 | | | | | | | |
| Total | | 0.45 | 0.55 | 1.12 | 0.66 | 0.66 | 1.32 | 0.61 | 0.26 | 0.92 | 0.59 | 0.64 |

* expressed as number of organisms/$m^3$ of water in drift column.

** MATACIL 1.8F®X + Atlox 3409F + Rhodamine B Dye + Water applied at 0840-0845 EDT on 16 June 1981.

RES restrictor drift left overnight, 16-17 June 1981.

L larvae
P pupae
N nymphs
A adults

Table 7.

Aquatic invertebrates collected in drift net sets*
Fourth Application, Control Site,
7-8 July 1981.

| Sample | | Pre | 0 | +½h | +1h | +1½h | +2h | +3h | +4h | +5h | +6h | RES |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Volume of drift column ($m^3$) | | 18.6 | 18.6 | 18.6 | 27.8 | 27.8 | 27.8 | 27.8 | 27.8 | 27.8 | 27.8 | 119.5 |
| Annelida: Oligochaeta | | | | | | | | | 0.04 | | | |
| Hydracarina | | | | | | 0.04 | | | | | 0.04 | 0.01 |
| Collembola | | | | | | 0.11 | | | | | | 0.04 |
| Plecoptera: Leuctridae | N | | | | | 0.04 | | | | | | |
| Taenopterygidae | N | | | | | 0.04 | | | 0.04 | | | |
| Ephemeroptera: Baetidae | N | | | | 0.04 | | | 0.04 | | 0.04 | 0.04 | 0.01 |
| Ephemerellidae | N | | | | | | | | | | | 0.01 |
| Odonata: Gomphidae | N | | | | | 0.07 | | | | | | |
| Megaloptera: Sialidae | L | | | | | 0.04 | | | | | | |
| Trichoptera: Glossosomatidae | L | | | | 0.04 | | | | | | | |
| Limnephilidae | L | | | | | | | | 0.04 | | | |
| Philopotamidae | L | | | | | | | | | 0.04 | | |
| Coleoptera: Dytiscidae | L | | | | 0.04 | | | | | | | |
| Diptera: Chironomidae | L | 0.75 | 0.22 | 0.16 | 0.36 | 0.36 | 0.18 | 0.07 | 0.18 | 0.18 | | 0.13 |
| | P | 0.11 | 0.05 | | 0.04 | | | 0.04 | | | | 0.01 |
| Dixidae | L | | | | | | | | | 0.04 | | |
| Empididae | L | 0.05 | | | 0.04 | | | | | | 0.43 | |
| Heleidae | L | | | | | 0.07 | | | | | 0.04 | |
| Simuliidae | L | 0.05 | | | 0.04 | | 0.07 | | | | | 0.08 |
| Total | | 0.97 | 0.27 | 0.16 | 0.58 | 0.78 | 0.25 | 0.14 | 0.29 | 0.29 | 0.54 | 0.29 |

* Expressed as number of organisms/$m^3$ of water in drift column.
RES restrictor drift left overnight, 7-8 July 1981.
L larvae
P pupae
N nymphs
A adults

# Table 8.

Aquatic invertebrates collected in drift net sets*
Fourth Application, Treated Site**,
7-8 July 1981

| Sample | | Pre | 0 | +½h | +1h | +1½h | +2h | +3h | +4h | +5h | +6h | RES |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Volume of drift column ($m^3$) | | 23.3 | 34.9 | 34.9 | 34.9 | 34.9 | 34.9 | 34.9 | 34.9 | 34.9 | 34.9 | 182.3 |
| Annelida: Hirudinea | | | | | | | | | | | | <0.01 |
| Oligochaeta | | 0.04 | | | | | | | | | | |
| Hydracarina | | | 0.17 | 0.06 | | | | 0.03 | 0.03 | 0.03 | | 0.01 |
| Collembola | | | 4.38 | 1.03 | 0.40 | 0.09 | 0.06 | | | | | |
| Plecoptera: Leuctridae | N | | 0.03 | 0.03 | | | | 0.03 | | | | <0.01 |
| Ephemeroptera: Baetidae | N | 0.04 | 0.11 | 0.03 | | 0.03 | 0.09 | 0.06 | 0.03 | 0.03 | | 0.09 |
| Ephemerellidae | N | | | | | | | | | 0.03 | | |
| Leptophlebiidae | N | | | | | | | 0.03 | | | | |
| Odonata: Aeshnidae | N | | | | | | | | 0.03 | | | |
| Hemiptera: Corixidae | | | | | | | | | | | | 0.01 |
| Gerridae | | | 0.32 | 0.20 | 0.03 | 0.11 | 0.06 | 0.03 | 0.03 | 0.03 | | |
| Trichoptera: Brachycentridae | L | | | 0.03 | | | | | | | | |
| Glossosomatidae | L | | | | | | | | | 0.03 | | |
| Hydroptilidae | L | | 0.03 | | 0.06 | | | | | | 0.03 | |
| Lepidostomatidae | L | | | | 0.03 | | | | | | 0.03 | |
| Limnephilidae | L | | | | | 0.03 | | | | | | 0.03 |
| Philopotamidae | L | | 0.03 | 0.17 | 0.09 | 0.03 | 0.03 | 0.11 | | | | 0.05 |
| Polycentropodidae | L | | | | | | | | | | | <0.01 |
| Rhyacophilidae | L | | | | | | | | | | | 0.01 |
| Coleoptera: Dytiscidae | L | | 0.03 | | 0.06 | | | | | | | |
| Elmidae | A | | | | | | | | | | | <0.01 |
| Haliplidae | A | | | | | | | | | | | <0.01 |
| Helodidae | A | | | | | | | | | | | <0.01 |
| Hydrophilidae | L | | | | | | | | | | 0.03 | |
| Diptera: Chironomidae | L | | 0.49 | 0.43 | 0.52 | 0.34 | 0.06 | 0.17 | 0.20 | 0.20 | 0.11 | 0.08 |
| | P | | 0.06 | | 0.03 | 0.06 | 0.03 | 0.03 | | 0.11 | | 0.01 |
| Dixidae | L | | | | | | | | | 0.03 | | |
| Heleidae | P | 0.04 | 0.03 | 0.06 | | | 0.03 | | | | | |
| Muscidae | L | 0.04 | | | | | | | | | | |
| Simuliidae | L | | | | 0.03 | | 0.03 | 0.03 | 0.03 | 0.06 | | |
| Tipulidae | L | 0.04 | 0.06 | 0.03 | | | | | | | | |
| Total | | 0.21 | 5.67 | 2.09 | 1.23 | 0.69 | 0.37 | 0.52 | 0.34 | 0.54 | 0.20 | 0.31 |

* Expressed as number of organisms/$m^3$ of water in drift column.
** MATACIL 1.8 D® + Automate Red Dye + Insecticide Diluent 585 applied at 0740-0745 EDT on 7 July 1981.
RES restrictor drift left overnight, 7-8 July 1981.
L larvae
P pupae
N nymphs
A adults

Table 9.

Aquatic invertebrates collected in drift net sets*
Fifth Application, Control Site,
14-17 July 1981

| Sample | | Pre | 0 | +½h | +1h | +1½h | +2h | +3h | +4h | +5h | +6h | RES 1 | RES 2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Volume of drift column ($m^3$) | | 8.9 | 14.8 | 14.8 | 14.8 | 14.8 | 15.5 | 15.5 | 14.8 | 14.8 | 14.8 | 43.9 | 106.0 |
| Nematomorpha | | | 0.07 | | | | | | | | | | |
| Hydracarina | | 0.11 | | | | | | | | | | | 0.01 |
| Collembola | | 0.11 | | | | | | | | | | | |
| Plecoptera: Leuctridae | N | 0.11 | | | | | | | | | | | |
| Ephemeroptera: Baetidae | N | | | 0.07 | | | 0.06 | 0.06 | | | 0.07 | 0.11 | 0.05 |
| Ephemerellidae | N | | | | | | | | | | | | 0.01 |
| Trichoptera: Glossosomatidae | L | | | | 0.07 | | | | | | | | |
| Hydroptilidae | L | | | 0.07 | | | | | | 0.07 | | 0.02 | |
| Coleoptera: Elmidae | A | | | | | 0.07 | | | | | | | |
| Diptera: Chironomidae | L | | 0.20 | 0.20 | 0.20 | | 0.06 | 0.13 | 0.14 | | 0.14 | 0.25 | 0.06 |
| | P | | | | | | | 0.13 | | | | | |
| Simuliidae | L | | | 0.07 | | | | | 0.07 | | | 0.07 | 0.02 |
| Total | | 0.34 | 0.27 | 0.40 | 0.27 | 0.07 | 0.13 | 0.32 | 0.20 | 0.07 | 0.20 | 0.43 | 0.14 |

* Expressed as number of organisms/$m^3$ of water in drift column.
RES 1 restrictor drift left overnight, 14-15 July 1981.
RES 2 restrictor drift left over two nights, 15-17 July 1981.
L larvae
P pupae
N nymphs
A adults

Table 10.

Aquatic invertebrates collected in drift net sets*,
Fifth Application, Treated Site**,
14-17 July 1981.

| Sample | | Pre | 0 | +½h | +1h | +1½h | +2h | +3h | +4h | +5h | +6h | RES 1 | RES 2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Volume of drift column ($m^3$) | | 12.7 | 13.0 | 13.6 | 13.6 | 13.6 | 13.3 | 13.0 | 13.3 | 13.0 | 13.3 | 33.8 | 70.2 |
| Hydracarina | | 0.31 | | | 0.15 | | | | | | 0.23 | | 0.03 |
| Collembola | | 0.08 | 0.08 | 0.07 | | | 0.07 | | 0.23 | 0.15 | 0.07 | 0.47 | 0.31 |
| Ephemeroptera: Baetidae | N | | | 0.15 | | | | | 0.07 | 0.08 | 0.07 | 0.86 | |
| Trichoptera: Hydroptilidae | L | | | | | | | | 0.07 | | | | 0.01 |
| Philopotamidae | L | | | | | | 0.15 | | | | | | |
| Diptera: Chironomidae | L | | | | 0.07 | 0.07 | 0.23 | 0.23 | 0.07 | 0.08 | | 0.32 | 0.04 |
| Dixidae | L | | | | | | | | | 0.08 | | | |
| Simuliidae | L | 0.08 | 0.08 | | | | | | | | | 0.03 | 0.03 |
| Total | | 0.47 | 0.15 | 0.22 | 0.22 | 0.07 | 0.45 | 0.23 | 0.45 | 0.38 | 0.38 | 1.69 | 0.43 |

* Expressed as number of organisms/$m^3$ of water in drift column.
** MATACIL 1.8 P® + Automate Red Dye + Insecticide Diluent 585 applied at 0755-0800 EDT on 14 July 1981.
RES 1 restrictor drift left overnight, 14-15 July 1981.
RES 2 restrictor drift left over two nights, 15-17 July 1981.
L larvae
P pupae
N nymphs
A adults

Table 11.

Aquatic invertebrates collected in drift net sets*
Sixth Application, Control Site,
21-24 July 1981

| Sample | | Pre | 0 | +½h | +1h | +1½h | +2h | +3h | +4h | +5h | +6h | RES 1 | RES 2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Volume of drift column ($m^3$) | | 27.1 | 28.7 | 29.9 | 31.4 | 30.2 | 29.1 | 29.1 | 29.1 | 27.1 | 27.1 | 72.7 | 135.4 |
| Hydracarina | | 0.15 | 0.14 | 0.03 | | | 0.03 | | 0.03 | 0.07 | 0.11 | 0.04 | 0.13 |
| Collembola | | 0.74 | 0.24 | 0.10 | | | 0.21 | | 0.24 | | 0.07 | 0.25 | 0.18 |
| Plecoptera: Chloroperlidae | N | | | | | | | | | | | 0.03 | 0.01 |
| Ephemeroptera: Baetidae | N | 0.04 | 0.03 | 0.03 | 0.03 | 0.03 | | | | 0.04 | | 0.12 | 0.08 |
| Ephemerellidae | N | | | | | 0.03 | | | | 0.04 | | | |
| Hemiptera: Gerridae | | | | | | | | | | | | 0.03 | 0.01 |
| Trichoptera: Hydropsychidae | L | | | | | | | | | | 0.04 | | |
| Hydroptilidae | L | | | | | | | | | 0.04 | | | |
| Coleoptera: Elmidae | A | | | | | | | 0.03 | | | | | |
| Diptera: Chironomidae | L | 0.11 | | 0.03 | 0.03 | | | 0.14 | | 0.18 | | 0.37 | 0.14 |
| Simulidae | L | 0.07 | | | 0.06 | 0.03 | | 0.10 | | | 0.04 | 0.14 | 0.04 |
| Total | | 1.11 | 0.42 | 0.20 | 0.13 | 0.10 | 0.24 | 0.27 | 0.27 | 0.37 | 0.26 | 0.98 | 0.59 |

* Expressed as number of organisms/$m^3$ of water in drift column.
RES 1 restrictor drift left overnight, 21-22 July 1981.
RES 2 restrictor drift left over two nights, 22-24 July 1981.
L larvae
P pupae
N nymphs
A adults

## Table 12.

Aquatic invertebrates collected in drift net secs*
Sixth Application, Treated Site**,
21-24 July 1981

| Sample | | Pre | 0, | -½h | +1h | +1½h | +2h | +3h | +4h | +5h | +6h | RES 1 | RES 2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Volume of drift column ($m^3$) | | 16.9 | 17.8 | 17.8 | 19.5 | 19.5 | 19.5 | 19.5 | 17.8 | 17.8 | 18.6 | 37.5 | 154.3 |
| Nematomorpha | | | | | | | | | 0.06 | | | | |
| Hydracarina | | 0.24 | 0.11 | | 0.46 | 0.36 | 0.26 | 0.15 | 0.28 | 0.56 | 0.16 | 0.38 | 0.07 |
| Collembola | | | | 0.11 | | 0.05 | | | | | | 0.02 | |
| Plecoptera: Chloroperlidae | N | | | | 0.10 | 0.10 | 0.20 | | | | | 0.05 | |
| Leuctridae | N | | | 0.06 | | 0.36 | 1.28 | 0.56 | 0.11 | | 0.05 | 0.02 | |
| Taeniopterygidae | N | | | | 0.10 | | | | | | | | |
| Ephemeroptera: Baetidae | N | | | 0.06 | 0.56 | 1.13 | 0.10 | | | | | 0.31 | 0.03 |
| Ephemerellidae | N | | | 0.06 | | | 0.05 | | | | | 0.07 | 0.01 |
| Leptophlebiidae | N | | | 0.11 | 0.05 | | | | | | | 0.16 | |
| Odonata: Cordulegastridae | N | | | | | | | | | 0.06 | | | |
| Hemiptera: Gerridae | | | | | | | | | | | | 0.03 | |
| Megaloptera: Sialidae | L | | | | | | | | | | | 0.02 | |
| Trichoptera: Glossosomatidae | L | | | | | 0.05 | | | | | | | |
| Hydroptilidae | L | | | | 0.10 | 0.05 | 0.31 | | | | | | |
| Limnephilidae | L | | | | | 0.10 | | | | | | 0.02 | |
| Philopotamidae | L | | | | 0.46 | | | | | | 0.05 | | |
| Phryganeidae | L | | | | | | 0.10 | 0.05 | | | | | |
| Psychomyiidae | L | | | | 0.05 | | | | | | | | |
| Rhyacophilidae | L | | | | | 0.05 | | | | | | | |
| Unidentified | L | | | | 0.05 | 0.10 | | | | | | | |
| Coleoptera: Dytiscidae | A | | | | | | | | | | | 0.02 | |
| Elmidae | A | | | | | | | | | | | 0.02 | |
| Diptera: Chironomidae | L | | 0.11 | 0.11 | 0.36 | 0.10 | 0.20 | 0.20 | 0.06 | 0.06 | 0.05 | 0.37 | 0.13 |
| | P | | | | | 0.05 | | | | | 0.05 | | |
| Empididae | L | | | | | | | | | 0.06 | | | |
| Heleidae | L | 0.06 | | | | | | | | | | 0.02 | |
| Simuliidae | L | | | | 17.38 | 0.67 | 0.15 | | 0.06 | | 0.11 | | 0.01 |
| Tipulidae | L | | | | 0.05 | 0.05 | | | | 0.06 | | | |
| Total | | 0.30 | 0.22 | 0.31 | 19.74 | 3.44 | 2.67 | 0.97 | 0.56 | 0.79 | 0.48 | 1.30 | 0.25 |

* Expressed as number of organisms/$m^3$ of water in drift column.
** MATACIL 1.8 F® + Atlox 3409 F + Rhodamine B Dye + Water applied at 0755-0800 EDT on 21 July 1981.
RES 1 restrictor drift left overnight, 21-22 July 1981.
RES 2 restrictor drift left over two nights, 22-24 July 1981.
L larvae
P pupae
N nymphs
A adults

## APPENDIX II

Benthic invertebrate population data from treated and control sites in Matt Brook for each aminocarb formulation application.

Aquatic invertebrates collected in Surber samples*,
First-Fifth Applications, Control Site,
3 June-15 July, 1981.

| | | Pre-spray 3 June | Post-spray 1 5 June | Post-spray 2 11 June | Post-spray 3 17 June | Post-spray 4 8 July | Post-spray 5 15 July |
|---|---|---|---|---|---|---|---|
| Turbellaria: Tricladida | | - | 0.25 ± 0.50 | - | - | - | - |
| Nematomorpha | | 0.50 ± 0.58 | - | - | - | - | 0.25 ± 0.50 |
| Annelida: Oligochaeta | | 6.50 ± 4.43 | 1.75 ± 3.50 | 0.50 ± 1.00 | - | 0.25 ± 0.50 | - |
| Hydracarina | | 0.75 ± 0.96 | - | - | - | 0.75 ± 1.50 | - |
| Plecoptera: Chloroperlidae | N | - | - | 0.25 ± 0.50 | - | - | 0.25 ± 0.50 |
| Leuctridae | N | 0.25 ± 0.50 | - | - | - | - | - |
| Ephemeroptera: Baetidae | N | 0.25 ± 0.50 | 0.50 ± 1.00 | - | - | 0.25 ± 0.50 | 0.25 ± 0.50 |
| Ephemerellidae | N | 0.25 ± 0.50 | - | - | - | 0.25 ± 0.50 | - |
| Odonata: Cordulegastridae | N | - | - | - | - | 0.25 ± 0.50 | 0.25 ± 0.50 |
| Trichoptera: Hydropsychidae | L | 0.50 ± 0.58 | 0.25 ± 0.50 | 0.25 ± 0.50 | - | - | 0.25 ± 0.50 |
| Hydroptilidae | L | 0.25 ± 0.50 | - | 1.00 ± 2.00 | - | - | - |
| Lepidostomatidae | L | - | - | - | - | - | 0.50 ± 1.00 |
| Limnephilidae | L | - | - | 0.50 ± 1.00 | - | - | 0.25 ± 0.50 |
| Psychomyiidae | L | - | 1.00 ± 2.00 | - | - | - | - |
| Rhyacophilidae | L | 1.50 ± 2.38 | 1.25 ± 1.26 | 1.50 ± 1.29 | - | 0.25 ± 0.50 | 0.25 ± 0.50 |
| Unidentified | P | 0.25 ± 0.50 | 0.25 ± 0.50 | - | - | - | 0.50 ± 1.00 |
| Diptera: Chironomidae | L | 8.50 ± 2.65 | 24.00 ± 27.54 | 19.75 ± 20.71 | 1.25 ± 1.26 | 12.00 ± 9.59 | 9.75 ± 5.91 |
| | P | - | - | 0.25 ± 0.50 | - | - | - |
| Dolichopodidae | L | 0.25 ± 0.50 | - | - | - | - | - |
| Empididae | L | 0.50 ± 0.58 | 0.75 ± 0.96 | 1.00 ± 0.82 | - | - | 0.25 ± 0.50 |
| | P | - | - | 0.50 ± 0.58 | - | - | 0.50 ± 1.00 |
| Heleidae | L | 0.50 ± 0.58 | 0.25 ± 0.50 | 0.50 ± 0.58 | - | 1.25 ± 2.50 | 0.75 ± 0.96 |
| Simulidae | L | - | 0.25 ± 0.50 | - | - | - | 0.50 ± 0.58 |
| Tabanidae | L | 1.75 ± 1.71 | 0.75 ± 0.96 | 0.25 ± 0.50 | - | 0.25 ± 0.50 | 0.25 ± 0.50 |
| Tipulidae | L | 1.00 ± 0.82 | 0.50 ± 1.00 | 0.50 ± 1.00 | - | 0.75 ± 1.50 | 1.75 ± 2.22 |
| Total | | 23.50 ± 9.26 | 31.75 ± 34.77 | 27.00 ± 19.85 | 1.25 ± 1.26 | 16.25 ± 13.40 | 16.50 ± 10.28 |

* mean numbers and standard deviations of organisms collected in four Surber samples.
L larvae
P pupae
N nymphs
A adults

Table 2.

Aquatic invertebrates collected from artificial substrates*,
First-Fifth Applications, Control Site,
3 June-15 July 1981.

| | | Pre-spray 3 June | Post-spray 1 5 June | Post-spray 2 11 June | Post-spray 3 17 June | Post-spray 4 8 July | Post-spray 5 15 July |
|---|---|---|---|---|---|---|---|
| Turbellaria: Tricladida | | - | 0.25 ± 0.50 | - | 0.25 ± 0.50 | 0.50 ± 0.58 | 3.00 ± 2.45 |
| Annelida: Oligochaeta | | - | - | - | - | 0.75 ± 0.50 | 0.25 ± 0.50 |
| Ostracoda | | 0.25 ± 0.50 | - | - | - | - | - |
| Hydracarina | | 0.75 ± 0.50 | 1.25 ± 1.26 | 0.50 ± 0.58 | 8.50 ± 4.43 | 6.25 ± 3.95 | 1.00 ± 1.41 |
| Plecoptera: Chloroperlidae | N | 1.25 ± 1.89 | 2.00 ± 2.00 | 0.25 ± 0.50 | 0.25 ± 0.50 | 1.25 ± 1.29 | 1.00 ± 1.41 |
| Leuctridae | N | 2.00 ± 2.16 | 3.00 ± 2.16 | 3.50 ± 5.00 | 2.00 ± 2.16 | 2.00 ± 2.16 | 4.00 ± 2.52 |
| Perlidae | N | - | - | - | - | - | - |
| Perlodidae | N | - | 0.25 ± 0.50 | 0.25 ± 0.50 | - | - | - |
| Taeniopterygidae | N | - | - | - | 8.75 ± 6.13 | - | - |
| Unidentified | N | - | - | 3.00 ± 4.69 | - | 0.50 ± 0.58 | - |
| Ephemeroptera: Baetidae | N | 4.25 ± 1.71 | 4.75 ± 3.59 | 2.50 ± 2.38 | 0.25 ± 0.50 | 0.50 ± 0.58 | 0.25 ± 0.50 |
| Ephemerellidae | N | 0.75 ± 0.96 | 1.00 ± 1.15 | 0.50 ± 1.00 | 2.00 ± 1.15 | 1.25 ± 1.26 | 0.50 ± 1.00 |
| Heptageniidae | N | - | 0.25 ± 0.50 | - | - | - | - |
| Leptophlebiidae | N | - | - | - | - | - | 0.75 ± 0.96 |
| Trichoptera: Hydropsychidae | L | - | 0.25 ± 0.50 | 0.25 ± 0.50 | - | - | - |
| Hydroptilidae | L | 6.75 ± 4.99 | 22.25 ± 10.05 | 18.25 ± 10.24 | 13.00 ± 6.88 | 0.50 ± 0.58 | 0.25 ± 0.50 |
| Lepidostomatidae | L | 0.75 ± 0.96 | - | - | 0.50 ± 0.58 | - | - |
| Limnephilidae | L | 0.25 ± 0.50 | - | - | - | - | - |
| Philopotamidae | L | 0.25 ± 0.50 | - | - | - | - | - |
| Psychomyiidae | L | - | - | - | - | - | 0.25 ± 0.50 |
| Rhyacophilidae | L | 0.25 ± 0.50 | 0.50 ± 1.00 | 0.50 ± 0.58 | 0.50 ± 1.00 | 0.50 ± 0.58 | 0.50 ± 1.00 |
| Unidentified | P | - | - | - | - | 1.00 ± 1.41 | 2.00 ± 2.16 |
| Coleoptera: Dytiscidae | L | - | - | - | - | 0.25 ± 0.50 | - |
| Elmidae | L | 0.25 ± 0.50 | - | - | - | - | - |
| Diptera: Chironomidae | L | 66.75 ± 20.22 | 73.75 ± 80.16 | 189.25 ± 122.59 | 171.25 ± 69.29 | 56.00 ± 24.91 | 94.25 ± 23.26 |
| | P | 1.00 ± 0.82 | 1.50 ± 0.58 | 0.75 ± 0.96 | 0.25 ± 0.50 | 2.00 ± 1.63 | 1.00 ± 0.82 |
| Empididae | L | 0.25 ± 0.50 | 0.75 ± 0.96 | 1.50 ± 1.29 | 2.25 ± 1.26 | 0.25 ± 0.50 | 0.75 ± 0.96 |
| | P | - | - | 0.25 ± 0.50 | - | - | 0.25 ± 0.50 |
| Heleidae | L | - | 0.75 ± 1.50 | 1.00 ± 0.82 | 0.25 ± 0.50 | 12.75 ± 7.09 | 9.50 ± 6.95 |
| Simulidae | L | - | - | 17.50 ± 35.00 | - | - | - |
| | P | - | - | 0.25 ± 0.50 | - | 0.50 ± 1.00 | - |
| Tipulidae | L | 1.00 ± 0.82 | 0.50 ± 1.00 | 1.00 ± 1.41 | 0.50 ± 1.00 | 0.75 ± 0.96 | 0.50 ± 0.58 |
| Total | | 86.75 ± 23.20 | 113.00 ± 88.35 | 241.00 ± 162.58 | 210.50 ± 77.69 | 87.75 ± 33.01 | 120.50 ± 21.46 |

* mean numbers and standard deviations of organisms collected from four artificial substrates.

L larvae
P pupae
N nymphs
A adults

Table 3.

Aquatic invertebrates collected in Surber samples*,
First Application, Treated Site**,
3 and 5 June 1981.

| | | Pre-spray - 1 day | Post-spray + 1 day |
|---|---|---|---|
| Nematamorpha | | - | 0.50 ± 0.58 |
| Hydracarina | | 0.25 ± 0.50 | - |
| Plecoptera: Leuctridae | N | 0.50 ± 1.00 | 0.25 ± 0.50 |
| Ephemeroptera: Ephemerellidae | N | 0.25 ± 0.50 | - |
| Odonata: Cordulegastridae | N | 0.75 ± 0.96 | - |
| Trichoptera: Hydroptilidae | L | 0.50 ± 0.58 | - |
| Lepidostomatidae | L | - | 0.50 ± 0.58 |
| Limnephilidae | L | 2.25 ± 2.63 | 0.50 ± 0.58 |
| Rhyacophilidae | L | 0.25 ± 0.50 | - |
| Unidentified | P | 0.75 ± 1.50 | - |
| Coleoptera: Elmidae | L | - | 0.25 ± 0.50 |
| Diptera: Chironomidae | L | 26.5 ± 11.93 | 12.75 ± 7.63 |
| | P | 2.00 ± 0.82 | 0.25 ± 0.50 |
| Dolichopodidae | L | 0.25 ± 0.50 | - |
| Empididae | L | 1.75 ± 1.26 | 0.75 ± 0.50 |
| Heleidae | L | 0.75 ± 0.96 | - |
| | P | - | 0.25 ± 0.50 |
| Tabanidae | L | 1.50 ± 1.29 | - |
| Tipulidae | L | 0.50 ± 0.58 | 0.25 ± 0.50 |
| Total | | 39.00 ± 7.35 | 16.25 ± 9.11 |

*mean numbers and standard deviations of organisms collected in four Surber samples.

**Sunspray 7-N + Automate Red Dye + Insecticide Diluent 585 applied at 0745-0750 EDT on 4 June 1981.

L larvae
P pupae
N nymphs
A adults

Table 4.

Aquatic invertebrates collected from artificial substrates*,
First Application, Treated Site**,
3 and 5 June 1981.

| | | Pre-spray - 1 day | Post-spray + 1 day |
|---|---|---|---|
| Nematomorpha | | - | 0.25 ± 0.50 |
| Ostracoda | | 0.75 ± 1.50 | - |
| Hydracarina | | 0.50 ± 1.00 | 0.50 ± 0.58 |
| Plecoptera: Chloroperlidae | N | 0.50 ± 0.58 | 0.50 ± 0.58 |
| Leuctridae | N | 2.00 ± 1.41 | 3.25 ± 0.50 |
| Perlodidae | N | 0.25 ± 0.50 | - |
| Ephemeroptera: Baetidae | N | 1.50 ± 1.73 | 2.00 ± 1.83 |
| Ephemerellidae | N | 1.00 ± 0.82 | 1.75 ± 0.50 |
| Leptophlebiidae | N | 0.50 ± 1.00 | 0.25 ± 0.50 |
| Odonata: Cordulegastridae | N | - | 0.25 ± 0.50 |
| Trichoptera: Hydroptilidae | N | 4.50 ± 2.38 | 5.00 ± 2.90 |
| Lepidostomatidae | N | 0.50 ± 0.58 | 0.50 ± 0.58 |
| Coleoptera: Dytiscidae | L | - | 0.25 ± 0.50 |
| Diptera: Chironomidae | L | 48.00 ± 8.60 | 103.50 ± 119.63 |
| | P | 1.00 ± 0.82 | 1.75 ± 1.26 |
| Empididae | L | 0.50 ± 0.58 | 1.00 ± 1.15 |
| Heleidae | L | - | 1.00 ± 1.15 |
| Tipulidae | L | 0.25 ± 0.50 | 0.25 ± 0.50 |
| Total | | 61.75 ± 12.39 | 122.00 ± 124.57 |

*mean numbers and standard deviations of organisms collected from four artificial substrates.

**Sunspray 7-N + Automate Red Dye + Insecticide Diluent 585 applied at 0745-0750 EDT on 4 June 1981.

L larvae
P pupae
N nymphs
A adults

Table 5.

Aquatic invertebrates collected in Surber samples*,
Second Application, Treated Site**,
9 and 11 June 1981.

| | | Pre-spray - 1 day | | Post-spray + 1 day | |
|---|---|---|---|---|---|
| Annelida: Oligochaeta | | 1.50 ± | 1.73 | 1.00 ± | 1.41 |
| Plecoptera: Chloroperlidae | | - | | 0.25 ± | 0.50 |
| Ephemeroptera: Baetidae | N | - | | 0.50 ± | 0.58 |
| Trichoptera: Hydrosychidae | L | - | | 0.50 ± | 1.00 |
| Hydroptilidae | L | 0.25 ± | 0.50 | 0.25 ± | 0.50 |
| Rhyacophilidae | L | - | | 0.50 ± | 0.58 |
| Diptera: Chironomidae | L | 3.50 ± | 4.51 | 7.25 ± | 4.50 |
| | P | 0.25 ± | 0.50 | 0.75 ± | 1.50 |
| Empididae | L | 0.25 ± | 0.50 | - | |
| Heleidae | L | 0.75 ± | 0.50 | 0.50 ± | 0.58 |
| Tabanidae | L | 0.25 ± | 0.50 | - | |
| Tipulidae | L | 0.25 ± | 0.50 | - | |
| Total | | 7.00 ± | 6.68 | 11.50 ± | 7.05 |

*mean numbers and standard deviations of organisms colected in four Surber samples.

**Sunspray 7-N + Atlox 3409 F + Rhodamine B Dye + Water applied at 0800-0805 EDT on 10 June 1981.

L larvae
P pupae
N nymphs
A adults

Table 6.

Aquatic invertebrates collected from artificial substrates*,
Second Application, Treated Site**,
9 and 11 June 1981.

| | | Pre-spray - 1 day | Post-spray + 1 day |
|---|---|---|---|
| Turbellaria: Tricladida | | - | 0.50 ± 0.58 |
| Nematomorpha | | 0.25 ± 0.50 | 0.25 ± 0.50 |
| Annelida: Oligochaeta | | 0.50 ± 0.58 | - |
| Hydracarina | | 7.75 ± 4.65 | 7.25 ± 7.63 |
| Plecoptera: Chloroperlidae | N | 1.00 ± 0.82 | 1.00 ± 1.15 |
| Taenopterygidae | N | 1.25 ± 0.50 | 1.75 ± 2.06 |
| Perlodidae | N | 0.75 ± 0.96 | - |
| Leuctridae | N | 7.25 ± 2.75 | 8.00 ± 9.13 |
| Ephemeroptera: Baetidae | N | 6.25 ± 5.50 | 1.50 ± 1.29 |
| Ephemerellidae | N | 3.00 ± 2.16 | 1.00 ± 2.00 |
| Odonata: Cordulegastridae | N | 0.25 ± 0.50 | - |
| Trichoptera: Hydropsychidae | L | 1.50 ± 1.73 | 1.75 ± 1.71 |
| Hydroptilidae | L | 28.00 ± 6.06 | 17.75 ± 13.72 |
| Lepidostomatidae | L | 0.75 ± 1.50 | - |
| Limnephilidae | L | 0.25 ± 0.50 | - |
| Rhyacophilidae | L | 0.25 ± 0.50 | 0.50 ± 0.58 |
| Coleoptera: Unidentified | P | 0.25 ± 0.50 | - |
| Diptera: Chironomidae | L | 178.75 ± 60.07 | 114.50 ± 75.54 |
| | P | 2.00 ± 2.16 | 1.00 ± 0.82 |
| Empididae | L | 2.00 ± 1.41 | 0.75 ± 0.50 |
| Heleidae | L | 4.25 ± 4.27 | 2.00 ± 2.83 |
| Simuliidae | L | 5.25 ± 6.70 | 13.25 ± 11.98 |
| Tipulidae | L | 2.50 ± 1.00 | 1.75 ± 0.50 |
| Total | | 254.00 ± 63.86 | 174.50 ± 100.31 |

*mean numbers and standard deviations of organisms collected from four artificial substrates.

**Sunspray 7-N + Atlox 3409 F + Rhodamine B Dye + Water applied at 0800-0805 EDT on 10 June 1981.

L larvae
P pupae
N nymphs
A adults

Table 7.

Aquatic invertebrates collected in Surber samples *,
Third Application, Treated Site**,
15 and 17 June 1981.

| | | Pre-spray - 1 day | Post-spray + 1 day |
|---|---|---|---|
| Turbellaria: Tricladida | | - | 0.25 ± 0.50 |
| Annelida: Oligochaeta | | 2.25 ± 5.00 | 1.00 ± 1.15 |
| Hydracarina | | - | 0.25 ± 0.50 |
| Plecoptera: Chloroperlidae | N | - | 0.50 ± 1.00 |
| Trichoptera: Hydropsychidae | L | 0.25 ± 0.50 | 0.25 ± 0.50 |
| Hydroptilidae | L | 0.25 ± 0.50 | 0.25 ± 0.50 |
| Limnephilidae | L | 0.25 ± 0.50 | - |
| Rhyacophilidae | L | 0.75 ± 0.96 | 0.75 ± 0.50 |
| Coleoptera: Chrysomelidae | L | - | 0.25 ± 0.50 |
| Elmidae | A | - | 0.25 ± 0.50 |
| Diptera: Chironomidae | L | 1.75 ± 1.50 | 2.25 ± 0.96 |
| | P | 0.25 ± 0.50 | - |
| Dolichopodidae | L | 0.25 ± 0.50 | - |
| Empididae | L | - | 0.25 ± 0.50 |
| Heleidae | L | - | 0.25 ± 0.50 |
| | P | - | 0.25 ± 0.50 |
| Simuliidae | L | 0.25 ± 0.50 | 0.50 ± 0.58 |
| Tabanidae | L | - | 0.25 ± 0.50 |
| Tipulidae | L | 0.75 ± 0.96 | - |
| Total | | 7.00 ± 3.56 | 7.50 ± 2.38 |

* mean numbers and standard deviations of organisms collected in four Surber samples.

** MATACIL 1.8F®X + Atlox 3409F + Rhodamine B Dye + Water applied at 0840-0845 on 16 June 1981.

L larvae
P pupae
N nymphs
A adults

Table 8.

Aquatic invertebrates collected from artificial substrates*,
Third Application, Treated Site**,
15 and 17 June 1981.

| | | Pre-spray − 1 day | Post-spray + 1 day |
|---|---|---|---|
| Nematomorpha | | 0.25 ± 0.50 | - |
| Annelida: Oligochaeta | | 0.25 ± 0.50 | 0.25 ± 0.50 |
| Hydracarina | | 2.50 ± 1.29 | 9.50 ± 4.73 |
| Plecoptera: Chloroperlidae | N | 0.25 ± 0.50 | - |
| Leuctridae | N | 14.00 ± 3.37 | 14.00 ± 4.97 |
| Perlodidae | N | 0.25 ± 0.50 | - |
| Taeniopterygidae | N | 2.25 ± 2.22 | 2.00 ± 2.00 |
| Ephemeroptera: Baetidae | N | 0.75 ± 0.96 | 0.25 ± 0.50 |
| Ephemerellidae | N | 0.50 ± 0.58 | 0.50 ± 0.58 |
| Trichoptera: Hydropsychidae | L | 0.25 ± 0.50 | 0.25 ± 0.50 |
| Hydroptilidae | L | 32.25 ± 7.80 | 24.75 ± 13.05 |
| Lepidostomatidae | L | - | 0.50 ± 0.58 |
| Limnephilidae | L | 0.75 ± 0.96 | - |
| Philopotamidae | L | 0.50 ± 0.58 | 1.00 ± 1.41 |
| Rhyacophilidae | L | 1.25 ± 0.50 | 0.75 ± 0.96 |
| Coleoptera: Dytiscidae | L | 0.25 ± 0.50 | 0.25 ± 0.50 |
| Diptera: Chironomidae | L | 175.50 ± 84.85 | 217.50 ± 72.85 |
| | P | 1.50 ± 1.00 | 0.50 ± 1.00 |
| Empididae | L | 1.00 ± 0.82 | 1.50 ± 0.58 |
| Heleidae | L | 1.00 ± 0.82 | 1.75 ± 1.50 |
| Simuliidae | L | 5.50 ± 6.14 | 1.75 ± 1.26 |
| Tabanidae | L | - | 0.25 ± 0.50 |
| Tipulidae | L | 2.25 ± 1.26 | 1.50 ± 0.58 |
| Total | | 243.00 ± 92.39 | 279.00 ± 87.00 |

* mean numbers and standard deviations of organisms collected from four artificial substrates.

** MATACIL 1.8F® X + Atlox 3409F + Rhodamine B Dye + Water applied at 0840-0845 on 16 June 1981.

L larvae
P pupae
N nymphs
A adults

Table 9.

Aquatic invertebrates collected in Surber samples*,
Fourth Application, Treated Site**,
6 and 8 July 1981.

| | | Pre-spray - 1 day | Post-spray + 1 day |
|---|---|---|---|
| Nematomorpha | | 0.50 ± 0.58 | 1.25 ± 1.50 |
| Annelida: Oligochaeta | | 3.50 ± 2.52 | 2.50 ± 1.29 |
| Hydracarina | | 1.00 ± 1.41 | 1.00 ± 0.82 |
| Plecoptera: Chloroperlidae | N | 0.25 ± 0.50 | - |
| Ephemeroptera: Baetidae | N | - | 0.25 ± 0.50 |
| Trichoptera: Rhyacophilidae | L | 0.25 ± 0.50 | 0.50 ± 0.58 |
| Unidentified | P | 0.25 ± 0.50 | - |
| Diptera: Chironomidae | L | 17.25 ± 11.27 | 23.75 ± 19.55 |
| | P | 0.50 ± 1.00 | - |
| Dolichopodidae | L | - | 0.25 ± 0.50 |
| Empididae | L | - | 0.25 ± 0.50 |
| | P | 0.50 ± 1.00 | - |
| Heleidae | L | 2.50 ± 1.91 | 5.25 ± 5.32 |
| Simuliidae | L | 1.25 ± 2.50 | 0.25 ± 0.50 |
| Tipulidae | L | 0.50 ± 0.58 | 1.25 ± 1.89 |
| Total | | 28.25 ± 18.59 | 36.50 ± 27.96 |

*mean numbers and standard deviations of organisms collected in four Surber samples.

**MATACIL 1.8 D® + Automate Red Dye + Insecticide Diluent 585 applied at 0740-0745 EDT on 7 July 1981.

L larvae
P pupae
N nymphs
A adults

Table 10.

Aquatic invertebrates collected from artificial substrates*,
Fourth Application Treated Site**,
6 and 8 July 1981.

| | | Pre-spray - 1 day | Post-spray + 1 day |
|---|---|---|---|
| Annelida: Oligochaeta | | - | 0.50 ± 0.58 |
| Hydracarina | | 1.00 ± 0.82 | 2.75 ± 2.06 |
| Plecoptera: Chloroperlidae | N | 1.00 ± 1.15 | 0.50 ± 0.58 |
| Leuctridae | N | 4.50 ± 2.38 | 1.75 ± 1.26 |
| Taeniopterygidae | N | 2.75 ± 2.87 | 1.00 ± 0.82 |
| Ephemeroptera: Baetidae | N | 5.75 ± 5.56 | 1.25 ± 1.26 |
| Ephemerellidae | N | 5.75 ± 2.87 | 1.75 ± 1.50 |
| Trichoptera: Hydropsychidae | L | - | 0.25 ± 0.50 |
| Hydroptilidae | L | 0.25 ± 0.50 | 0.50 ± 0.58 |
| Philopotamidae | L | 0.25 ± 0.50 | 0.50 ± 0.58 |
| Rhyacophilidae | L | 0.50 ± 1.00 | 0.75 ± 0.50 |
| Unidentified | P | - | 0.25 ± 0.50 |
| Diptera: Chironomidae | L | 299.00 ± 154.78 | 73.75 ± 63.55 |
| | P | 2.00 ± 1.41 | 2.00 ± 2.71 |
| Empididae | L | - | 0.25 ± 0.50 |
| Heleidae | L | 6.00 ± 8.04 | 10.50 ± 8.81 |
| Simuliidae | L | 11.25 ± 13.30 | 2.25 ± 0.96 |
| | P | 2.00 ± 3.37 | - |
| Tipulidae | L | 0.50 ± 0.58 | 1.00 ± 0.82 |
| Total | | 341.75 ± 158.13 | 101.50 ± 71.38 |

*mean numbers and standard deviations of organisms collected from four artificial substrates.

**MATACIL 1.8 D® + Automate Red Dye + Insecticide Diluent 585 applied at 0740-0745 EDT on 7 July 1981.

L larvae
P pupae
N nymphs
A adults

Table 11.

Aquatic invertebrates collected in Surber samples*,
Fifth Application, Treated Site**,
13 and 15 July, 1981.

| | | Pre-spray - 1 day | Post-spray + 1 day |
|---|---|---|---|
| Turbellaria: Tricladida | | 0.50 ± 0.58 | - |
| Plecoptera: Leuctridae | N | 0.50 ± 1.00 | 0.25 ± 0.58 |
| Taeniopterygidae | N | 0.25 ± 0.50 | - |
| Ephemeroptera: Baetidae | N | 0.50 ± 1.00 | 0.25 ± 0.58 |
| Trichoptera: Lepidostomatidae | L | 0.25 ± 0.50 | - |
| Philopotamidae | L | 0.50 ± 1.00 | - |
| Rhyacophilidae | L | - | 0.50 ± 0.58 |
| Coleoptera: Dytiscidae | L | - | 0.25 ± 0.50 |
| Diptera: Chironomidae | L | 2.50 ± 3.11 | 3.25 ± 9.57 |
| Heleidae | L | - | 0.25 ± 0.50 |
| Muscidae | L | 0.25 ± 0.50 | - |
| Tabanidae | L | 0.25 ± 0.50 | - |
| Tipulidae | L | - | 0.25 ± 0.50 |
| Total | | 5.50 ± 4.43 | 5.25 ± 1.50 |

*mean numbers and standard deviations of organisms collected in four Surber samples.

**MATACIL 1.8 F® + Automate Red Dye + Insecticide Diluent 585 applied at 0755-0800 EDT on 14 July 1981.

L larvae
P pupae
N nymphs
A adults

Table 12.

Aquatic invertebrates collected from artificial substrates*,
Fifth Application, Treated Site**,
13 and 15 July 1981.

| | | Pre-spray - 1 day | Post-spray + 1 day |
|---|---|---|---|
| Turbellaria: Tricladida | | 12.75 ± 17.46 | 1.75 ± 1.71 |
| Annelida: Oligochaeta | | - | 1.25 ± 9.57 |
| Ostracoda | | - | 0.25 ± 0.50 |
| Hydracarina | | 1.50 ± 1.00 | 6.00 ± 2.16 |
| Plecoptera: Chloroperlidae | N | 1.50 ± 2.38 | 1.25 ± 0.50 |
| Leuctridae | N | 3.50 ± 2.52 | 14.50 ± 11.09 |
| Taeniopterygidae | N | 0.25 ± 0.50 | 0.25 ± 0.50 |
| Ephemeroptera: Baetidae | N | 0.25 ± 0.50 | 0.25 ± 0.50 |
| Ephemerellidae | N | - | 0.50 ± 0.58 |
| Leptophlebiidae | N | 0.50 ± 1.00 | 1.00 ± 1.41 |
| Megaloptera: Sialidae | L | - | 0.25 ± 0.50 |
| Trichoptera: Hydropsychidae | L | 0.25 ± 0.50 | - |
| Limnephilidae | L | - | 0.25 ± 0.50 |
| Rhyacophilidae | L | 0.75 ± 0.96 | 0.75 ± 0.50 |
| Unidentified | P | 0.50 ± 0.58 | - |
| Coleoptera: Dytiscidae | L | - | 0.25 ± 0.50 |
| Diptera: Chironomidae | L | 88.00 ± 50.35 | 101.00 ± 61.86 |
| | P | 0.75 ± 0.96 | 1.00 ± 1.41 |
| Empididae | L | 0.75 ± 0.96 | 1.00 ± 0.82 |
| | P | - | 0.25 ± 0.50 |
| Heleidae | L | 2.25 ± 3.20 | 9.75 ± 3.30 |
| Muscidae | L | 0.25 ± 0.50 | - |
| Simuliidae | P | - | 0.25 ± 0.50 |
| Tipulidae | L | 1.75 ± 2.36 | 0.50 ± 0.58 |
| Total | | 115.5 ± 52.89 | 142.25 ± 74.56 |

*mean numbers and standard deviations of organisms collected from four artificial substrates.

**MATACIL 1.8 F® + Automate Red Dye + Insecticide Diluent 585 applied at 0755-0800 EDT on 14 July 1981.

L larvae
P pupae
N nymphs
A adults

Aquatic invertebrates collected in Surber samples*,
Sixth Application, Control Site,
20 July-2 August 1981.

| | | Pre-spray - 1 day | Post-spray + 1 day | Post-spray + 12 days |
|---|---|---|---|---|
| Nematomorpha | | - | 0.25 ± 0.50 | 0.25 ± 0.50 |
| Annelida: Oligochaeta | | 1.25 ± 1.89 | 1.00 ± 0.82 | 0.75 ± 1.50 |
| Hydracarina | | - | 0.75 ± 1.50 | - |
| Plecoptera: Chloroperlidae | N | 0.25 ± 0.50 | 0.25 ± 0.50 | 0.75 ± 0.50 |
| Leuctridae | N | 0.50 ± 1.00 | 0.25 ± 0.50 | 0.50 ± 0.58 |
| Ephermeroptera: Ephemerellidae | N | 0.50 ± 0.58 | - | 0.25 ± 0.50 |
| Trichoptera: Hydroptilidae | L | - | - | 5.25 ± 2.87 |
| Limnephilidae | L | 0.25 ± 0.50 | 1.75 ± 0.96 | - |
| Pschoymiidae | L | 1.50 ± 3.00 | - | - |
| Rhyacophilidae | L | - | 0.25 ± 0.50 | - |
| Unidentified | P | 0.25 ± 0.50 | - | - |
| Coleoptera: Elmidae | L | - | - | 0.25 ± 0.50 |
| Diptera: Chironomidae | L | 21.74 ± 16.48 | 5.75 ± 5.19 | 2.00 ± 1.41 |
| | P | - | - | 0.25 ± 0.50 |
| Dixidae | L | - | - | 0.25 ± 0.50 |
| Empididae | L | 0.25 ± 0.50 | - | - |
| Heleidae | L | 0.50 ± 1.00 | 3.50 ± 3.70 | 1.50 ± 1.73 |
| Simulidae | L | 0.25 ± 0.50 | - | - |
| Tabanidae | L | - | - | 0.75 ± 0.96 |
| Tipulidae | L | 1.00 ± 1.15 | 1.50 ± 1.29 | 4.50 ± 2.38 |
| Total | | 28.25 ± 21.72 | 15.25 ± 13.00 | 17.75 ± 7.46 |

* mean numbers and standard deviations of organisms collected in four Surber samples.
L larvae
P pupae
N nymphs
A adults

Table 14.

Aquatic invertebrates collected from artificial substrates*,
Sixth Application, Control Site
20 July-2 August 1981.

| | | Pre-spray - 1 day | Post-spray + 1 day | Post-spray + 12 days |
|---|---|---|---|---|
| Turbellaria: Tricladida | | - | 0.75 ± 0.96 | - |
| Annelida: Oligochaeta | | - | 0.25 ± 0.50 | - |
| Hydracarina | | 1.50 ± 3.00 | 3.75 ± 3.10 | 8.75 ± 4.03 |
| Plecoptera: Chloroperlidae | N | 0.75 ± 0.50 | 0.75 ± 0.50 | 3.50 ± 1.91 |
| Leuctridae | N | 1.75 ± 1.50 | 4.25 ± 3.86 | 3.75 ± 3.30 |
| Ephemeroptera: Baetidae | N | 0.50 ± 0.58 | 3.75 ± 2.63 | 2.00 ± 3.37 |
| Ephemerellidae | N | - | - | 0.50 ± 0.58 |
| Leptophlebiidae | N | - | 1.00 ± 1.41 | - |
| Odonata: Aeshnidae | N | 0.25 ± 0.50 | - | - |
| Trichoptera: Hydroptilidae | L | - | - | 0.50 ± 0.58 |
| Lepidostomatidae | L | - | 0.25 ± 0.50 | - |
| Limnephilidae | L | 0.25 ± 0.50 | - | - |
| Unidentified | L | - | - | 1.75 ± 1.50 |
| Diptera: Chironomidae | L | 27.75 ± 19.35 | 73.00 ± 66.25 | 18.00 ± 12.03 |
| | P | 0.50 ± 1.00 | 1.00 ± 1.15 | - |
| Heleidae | L | 5.75 ± 4.27 | 7.75 ± 3.20 | 9.25 ± 2.50 |
| Tipulidae | L | 1.75 ± 1.71 | 0.75 ± 0.96 | 0.25 ± 0.50 |
| Total | | 40.75 ± 18.36 | 97.25 ± 67.17 | 48.25 ± 21.06 |

* mean numbers and standard deviations of organisms collected from four artificial substrates.

L larvae
P pupae
N nymphs
A adults

Aquatic invertebrates collected in Surber samples,*
Sixth Application, Treated Site**,
20 July-2 August, 1981.

| | | Pre-spray − 1 day | Post-spray + 1 day | Post-spray + 12 days |
|---|---|---|---|---|
| Turbellaria: Tricladida | | 2.25 ± 3.30 | 0.25 ± 0.50 | − |
| Nematomorpha | | 0.50 ± 1.00 | 0.25 ± 0.50 | − |
| Annelida: Oligochaeta | | 0.75 ± 0.96 | 2.75 ± 1.50 | 1.50 ± 2.38 |
| Hydracarina | | − | 0.75 ± 0.50 | 1.75 ± 1.50 |
| Plecoptera: Chloroperlidae | N | 1.50 ± 2.38 | 0.25 ± 0.50 | 0.50 ± 1.00 |
| Leuctridae | N | 0.50 ± 1.00 | − | 1.25 ± 1.89 |
| Taeniopterygydiae | N | − | − | 1.25 ± 1.89 |
| Ephemeroptera: Baetidae | N | − | − | 0.25 ± 0.50 |
| Ephemerellidae | N | 0.50 ± 1.00 | − | − |
| Odonata: Cordulegastridae | N | − | − | 0.50 ± 0.58 |
| Trichoptera: Hydroptilidae | L | − | − | 0.75 ± 0.96 |
| Lepidostomatidae | L | − | 0.25 ± 0.50 | − |
| Limnephilidae | L | 0.50 ± 1.00 | 0.25 ± 0.50 | 0.25 ± 0.50 |
| Psychomyiidae | L | 0.25 ± 0.50 | − | − |
| Rhyacophilidae | L | 0.25 ± 0.50 | − | − |
| Diptera: Chironomidae | L | 23.25 ± 15.59 | 11.25 ± 8.69 | 3.50 ± 3.87 |
| | P | − | − | 2.50 ± 2.38 |
| Empididae | L | 0.75 ± 0.50 | 0.50 ± 0.58 | 0.25 ± 0.50 |
| Heleidae | L | 0.50 ± 0.58 | 1.50 ± 1.00 | 1.00 ± 2.00 |
| Simuliidae | L | 2.25 ± 1.71 | − | − |
| Tabanidae | L | 1.00 ± 0.82 | 0.50 ± 0.58 | − |
| Tipulidae | L | 2.50 ± 1.29 | 4.75 ± 4.50 | 2.00 ± 2.71 |
| Gastropoda | | 0.25 ± 0.50 | − | − |
| Total | | 37.50 ± 9.68 | 23.25 ± 15.92 | 17.25 ± 13.23 |

* mean numbers and standard deviations of organisms collected in four Surber samples.
** MATACIL 1.8F® + Atlox 3409 F + Rhodamine B Dye + Water applied at 0755-0800 EDT on 21 July 1981.
L larvae
P pupae
N nymphs
A adults

Table 16.

Aquatic invertebrates collected in artificial substrate samples*,
Sixth Application, Treated Site**,
20 July-2 August 1981.

| | | Pre-spray − 1 day | Post-spray + 1 day | Post-spray + 12 days |
|---|---|---|---|---|
| Turbellaria: Tricladida | | 3.75 ± 3.86 | 1.75 ± 2.22 | 0.75 ± 1.50 |
| Nematomorpha | | − | 0.50 ± 1.00 | 0.50 ± 1.00 |
| Annelida: Oligochaeta | | − | 0.25 ± 0.50 | 1.75 ± 1.71 |
| Ostracoda | | − | − | 1.50 ± 3.00 |
| Hydracarina | | 3.75 ± 2.87 | 27.00 ± 13.29 | 42.00 ± 25.03 |
| Plecoptera: Chloroperlidae | N | 2.25 ± 1.26 | 1.25 ± 0.50 | 3.00 ± 1.83 |
| Leuctridae | N | 12.50 ± 7.14 | 12.00 ± 3.37 | 12.75 ± 5.06 |
| Taeniopterygidae | N | 0.25 ± 0.50 | 0.50 ± 1.00 | 17.00 ± 24.90 |
| Ephemeroptera: Baetidae | N | 1.75 ± 1.71 | 7.75 ± 7.14 | 10.75 ± 5.06 |
| Ephemerellidae | N | 0.25 ± 0.50 | 0.50 ± 0.58 | 1.50 ± 1.29 |
| Heptageniidae | N | − | − | 0.25 ± 0.50 |
| Leptophlebiidae | N | − | − | 1.00 ± 2.00 |
| Megaloptera: Sialidae | L | 0.25 ± 0.50 | − | 0.25 ± 0.50 |
| Trichoptera: Hydropsychidae | L | 0.25 ± 0.50 | 0.50 ± 0.58 | 0.25 ± 0.50 |
| Hydroptilidae | L | − | 0.25 ± 0.50 | 0.25 ± 0.50 |
| Limnephilidae | L | − | 0.25 ± 0.50 | − |
| Philopotamidae | L | − | 0.25 ± 0.50 | − |
| Polycentropodidae | L | − | − | 0.50 ± 1.00 |
| Rhyacophilidae | L | 0.50 ± 0.58 | 0.25 ± 0.50 | 1.50 ± 1.73 |
| Unidentified | L | − | − | 0.75 ± 0.50 |
| Coleoptera: Elmidae | L | − | − | 0.25 ± 0.50 |
| | A | − | − | 1.50 ± 3.00 |
| Diptera: Chironomidae | L | 364.75 ± 192.93 | 362.50 ± 261.75 | 69.25 ± 46.75 |
| | P | 0.75 ± 0.96 | 1.25 ± 0.50 | 1.75 ± 2.87 |
| Empididae | L | | | 0.25 ± 0.50 |
| | P | − | 0.25 ± 0.50 | − |
| Heleidae | L | 16.50 ± 5.20 | 6.50 ± 4.65 | 10.75 ± 4.50 |
| Rhagionidae | L | 0.25 ± 0.50 | − | − |
| Simuliidae | L | 0.50 ± 0.58 | 1.00 ± 0.82 | 1.75 ± 3.50 |
| Tabanidae | L | | 0.25 ± 0.50 | 0.25 ± 0.50 |
| Tipulidae | L | 2.50 ± 1.73 | 2.25 ± 2.06 | 4.50 ± 7.05 |
| Total | | 410.75 ± 201.43 | 427.00 ± 247.30 | 186.50 ± 95.6 |

* mean numbers and standard deviations of organisms collected from four artificial substrates.

** MATACIL 1.8F® + Atlox 3409F + Rhodamine B Dye + Water applied at 0755-0800 EDT on 21 July 1981.

L larvae
P pupae
N nymphs
A adults